

**TOPICAL PLAN  
FOR JINR RESEARCH  
AND INTERNATIONAL COOPERATION  
2017**

Dubna 2016

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Prepared by  
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All the themes in the Plan are listed by fields of research. Each theme is coded according to the JINR system of classification and contains the following information:

- the first number \* - the field of research
- the second number \*\* - the conventional number of Laboratory or other Division of JINR
- the third number - the theme's ordinal number
- the fourth and the fifth numbers - the years of the activity's beginning and completion

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<ul style="list-style-type: none"> <li>* 01 - Theoretical Physics</li> <li>02 - Elementary Particle Physics and Relativistic Nuclear Physics</li> <li>03 - Nuclear Physics</li> <li>04 - Condensed Matter Physics and Radiobiological Research</li> <li>05 - Networking, Computing, Computational Physics</li> <li>06 - Educational Programme</li> </ul>	<ul style="list-style-type: none"> <li>** 0 - All-Institute Topics</li> <li>1 - Veksler and Baldin Laboratory of High Energy Physics (VBLHEP)</li> <li>2 - Dzhelapov Laboratory of Nuclear Problems (DLNP)</li> <li>3 - Bogoliubov Laboratory of Theoretical Physics (BLTP)</li> <li>4 - Frank Laboratory of Neutron Physics (FLNP)</li> <li>5 - Flerov Laboratory of Nuclear Reactions (FLNR)</li> <li>6 - Laboratory of Information Technologies (LIT)</li> <li>8 - Science Organization Department (SOD)</li> <li>9 - Laboratory of Radiation Biology (LRB)</li> </ul>
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Theoretical  
Physics  
(01)

## Theory of Fundamental Interactions

### Leaders:

D.I. Kazakov  
O.V. Teryaev  
A.B. Arbuzov

### Participating Countries and International Organizations:

Armenia, Azerbaijan, Belarus, Bulgaria, Canada, CERN, China, Czech Republic, Finland, France, Georgia, Germany, Hungary, ICTP, Italy, Japan, Kazakhstan, Mexico, Mongolia, New Zealand, Norway, Poland, Republic of Korea, Russia, Serbia, Slovakia, Spain, Sweden, Switzerland, USA, Ukraine, United Kingdom, Uzbekistan, Vietnam.

### Scientific Programme

The main aim of the research within the theme is the construction of theoretical models and their application to the description of properties of elementary particles and their interactions. This research includes the following directions of activity. The development of quantum field theory formalism in gauge and supersymmetric theories. Construction and investigation of the models of particle physics beyond the Standard Model. Theoretical support of experiments at the Large Hadron Collider on the search of new physics and the study of the properties of the Higgs boson. Calculation of radiative corrections to the processes of particle creation within the Standard Model and its extensions. Investigation of neutrino properties and neutrino oscillations. Investigation of the hadron properties within quantum chromodynamics and phenomenological quark models. Study of the hadron spin structure with the help of generalized and transverse momentum dependent parton distributions. Study of heavy quark properties and exotic hadrons. Lattice simulations for obtaining nonperturbative results in gauge theories. Investigation of dense hadronic matter and theoretical support of the program NICA. Theoretical support of a wide range of current and future experiments at JINR, IHEP, CERN, GSI, DESY and other physics centers.

### Expected main results in 2017:

- Calculation of ultraviolet divergences in maximally supersymmetric gauge theories in extra dimensions in all orders of perturbation theory.  
Theoretical analysis of SUSY searches at LHC in the framework of the MSSM and the NMSSM based on experimental data from ATLAS and CMS.  
Investigation of the effects due to radiative corrections in Drell-Yan processes after increasing LHC luminosity and beam energy.  
Studies of  $Q^2$ -evolution of the average gluon and quark jet multiplicities with the double-logarithm resummation taken into account.  
Investigation of high-energy asymptotics of the structure function  $F_2$  and its heavy quark parts.  
Development of the method of incorporation of strong corrections in to physical observables at an arbitrary order of QCD perturbation theory within the dispersive approach.  
Development of a twistor description for form factors and off-shell amplitudes in theories with extended supersymmetry.  
Study and calculation of anomalous dimensions of twist 2 operators in the case of ABJM and orbifold deformations of N=4 SYM within the quantum spectral curve approach.  
Studies of the dark matter problem in the framework of the Standard Model and beyond it, including its supersymmetric generalizations. Building of Minimal Consistent Dark Matter models. Development of the strategy of comparing/mapping of their parameters for results of searches.



- Extraction of non-OPE QCD short string contributions to annihilation and decay processes using the standard and IR-modified couplings.  
Account for strange quark mass effects in the anomaly sum rules in space-like and time-like regions.  
Calculations for different mechanisms of exclusive Drell-Yan pairs production from NICA to LHC energies.  
Lattice calculations of transverse-momentum dependent distributions and hadron polarizabilities.  
Development of a complementary scheme of processing of low x data for spin-dependent structure functions based on truncated moments used.
- Calculation of the hadronic light-by-light contributions to the muon anomalous magnetic moment in the leading and next-to-leading orders in the  $1/N_c$  parameter.  
Investigation of meson creation at low energies at electron-positron beams.  
Calculations of widths of tau decays.  
Calculation of the contribution of anomalous quark-gluon chromomagnetic interaction to the single- and double- spin asymmetries for inclusive pion production in high energy proton-proton collisions.  
The glueball/Hybrid spectrum of the Hamiltonian of Dirac-Yang-Mills quantum mechanics of spatially constant fields, which constitutes to the lowest leading order in strong coupling, will be calculated with high precision for both the baby version of SU2 and the real case of SU3, using a systematic variational approach based on an orthonormal basis of trial states which are the exact analytical solutions of the corresponding harmonic oscillator problem.
- Participation (continuation) in the tmfT Collaboration (finite temperature with twisted mass fermions) aimed at description of the quark-gluon thermodynamics including strange and charmed quarks and consideration of new observables indicating the crossover.  
Study of the phenomenology of topological defects (Z(3) walls and associated strings) with metastable Z(3) domains based on lattice QCD calculations.  
Investigation of the contribution of topological degrees of freedom (monopoles, dyons, vortices) to the properties of strongly interacting quark-gluon plasma.  
Investigation of the influence of the glueballs to the properties of sQGP above the deconfinement temperature in hot/dense nuclear matter.  
Study of the generation of vorticity in heavy-ion collisions and its effect on P-odd correlations of quarks and mesons in the NICA energy range.  
Investigation of the role of color degrees of freedom at the early stage of heavy-ion interactions within the model of Parton Hadron String Dynamics (PHSD), estimation of the intensity of chromoelectric and chromomagnetic fields created in collisions of relativistic heavy ions.  
Investigation of observable manifestations of the nonperturbative gluon fields (domain walls and nontopological solitons) in the collisions of relativistic heavy ions. Study of the influence of electromagnetic fields on the formation of a heterophase mixed phase within the domain model of the QCD vacuum.  
The THESEUS programme will be used to generate events at NICA energies. The research will concern mainly the study of the new EoS and transport coefficients. Study of hybrid EoS (equations of state) based on ab-initio nuclear EoS and non-local PNJL models in a wide range of densities, temperatures and isospin asymmetry, applications in the simulation of heavy-ion collisions and supernova collapse and in compact star phenomenology.

## List of activities:

<b>Activity or experiment</b>	<b>Leaders</b>
<b>Laboratory or other</b>	<b>Main researchers</b>
<b>Division of JINR</b>	
<b>1. Standard Model and its extension</b>	<b>D.I. Kazakov</b> <b>A.B. Arbuzov</b>
BLTP	A.V. Bednyakov, A.V. Gladyshev, A.V. Kotikov, G.A. Kozlov, V.K. Mitrjushkin, V.A. Naumov, A.D. Popov, S.I. Vinitsky, + 5 students
LIT	V.P. Gerdt
VBLHEP	V.G. Krivokhizhin, B.G. Shaythatdenov, R.R. Ahunzyanov
DLNP	D.Yu. Bardin, V.A. Bednyakov, L.B. Kalinovskaya
<b>2. QCD parton distributions</b> <b>for modern and future colliders</b>	<b>A.V. Efremov</b> <b>O.V. Teryaev</b>
BLTP	M. Deka, S.V. Goloskokov, S.V. Mikhailov, A.V. Nesterenko, A.V. Radyushkin, O.V. Selyugin, A.V. Sidorov, + 3 students
VBLHEP	Yu.I. Ivanshin, I.A. Savin
DLNP	L.L. Nemenov, L.G. Tkatchev, A.S. Khrykin
<b>3. Physics of heavy and exotic</b> <b>hadrons</b>	<b>A.E. Dorokhov</b> <b>M.A. Ivanov</b>
BLTP	I.V. Anikin, G. Ganbold, S.B. Gerasimov, S.M. Eliseev, N.I. Kochelev, V.I. Korobov, V.A. Meshcheryakov, S.N. Nedelko, M.K. Volkov, Yu.S. Surovtsev, S.A. Zhaugasheva, + 5 students
VBLHEP	Yu.A. Panebratsev, M.V. Tokarev, V.A. Nikitin, Yu.I. Ivanshin, I.A. Savin, M.G. Sapozhnikov
DLNP	V.A. Bednyakov, N.B. Skachkov
<b>4. Hadron Matter under extreme</b> <b>conditions</b>	<b>E.-M. Ilgenfritz</b> <b>S.N. Nedelko</b> <b>D. Blaschke</b>
BLTP	D.E. Alvarez-Castillo, A.A. Golubtsova, M. Deka, A.E. Dorokhov, A.V. Friesen, M. Hasegawa, A.S. Khvorostukhin, N.I. Kochelev, A. Parvan, B.D. Rumiantsev, O.V. Teryaev, V.D. Toneev, A.M. Trunin, V.E. Voronin, + 3 students
LIT	A.S. Ayriyan, H. Grigorian, Yu.L. Kalinovskiy, Zh.Zh. Musulmanbekov, V. Voronyuk
VBLHEP	V.D. Kekelidze, A.G. Litvinenko, M.V. Tokarev, O.V. Rogachevsky
DLNP	G.I. Lykasov

## Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	RAU Foundation ANSL
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	INP BSU JIPNR-Sosny NASB BelSUT GSU GSTU
	Gomel	INRNE BAS SU
Bulgaria	Sofia	
Canada	Montreal	McGill UdeM U of T
CERN	Toronto	CERN
	Geneva	
Chile	Valparaiso	UV
China	Lanzhou	IMP CAS
	Wuhan	WIPM CAS
Czech Republic	Prague	CTU CU IP ASCR NPI ASCR
	Řež	
Finland	Helsinki	UH
France	Lyon	UCBL
	Metz	UPV-M
	Montpellier	UM2
	Paris	UPMC
	Saclay	SPhN CEA DAPNIA IRFU
Georgia	Tbilisi	RMI TSU
Germany	Berlin	FU Berlin HUB
	Aachen	RWTH
	Bielefeld	Univ.
	Bochum	RUB
	Bonn	UniBonn
	Dortmund	TU Dortmund
	Erlangen	FAU
	Hamburg	DESY Univ.
	Heidelberg	Univ.
	Jena	Univ.

	Jülich	FZJ
	Kaiserslautern	TU
	Karlsruhe	KIT
	Regensburg	UR
	Rostock	Univ.
	Mainz	JGU
	Munich	LMU
	Tübingen	Univ.
	Wuppertal	UW
	Zeuthen	DESY
Hungary	Budapest	ELTE
		Wigner RCP
ICTP	Trieste	ICTP
Italy	Bari	INFN
	Naples	INFN
	Padua	UniPd
	Pavia	INFN
	Pisa	INFN
	Trieste	SISSA/ISAS
	Turin	UniTo
Japan	Tokyo	UT
		Tokyo Tech
	Kyoto	Kyoto Univ.
	Nagoya	Meiji Univ.
		Nagoya Univ.
	Tsukuba	KEK
Kazakhstan	Almaty	APHI
		INP
	Astana	BA INP
Mexico	Cuernavaca	UNAM
Mongolia	Ulaanbaatar	IPT MAS
		NUM
New Zealand	Hamilton	Univ.
Norway	Trondheim	NTNU
Poland	Krakow	NINP PAS
	Kielce	JKU
	Lodz	UL
	Lublin	UMCS
	Otwock-Swierk	NCBJ
Republic of Korea	Seoul	SNU
	Daegu	KNU
	Chongju	CBNU
Russia	Moscow	IMM RAS
		ITEP
		LPI RAS

		MSU
		MI RAS
		PFUR
		SCC RAS
		SINP MSU
	Moscow, Troitsk	INR RAS
	Belgorod	BelSU
	Chernogolovka	LITP RAS
	Gatchina	PNPI
	Irkutsk	ISDCT SB RAS
	Ivanovo	ISC RAS
		ISU
	Kazan	KFU
	Novosibirsk	IM SB RAS
		BINP SB RAS
	Perm	PSNRU
	Protvino	IHEP
	Rostov-on-Don	SFedU
	St. Petersburg	SPbSU
		SPbSPU
	Samara	SSU
		SSAU
	Saratov	SSU
	Sarov	VNIIEF
	Tomsk	TSU
		IHCE SB RAS
	Tver	TvSU
	Yoshkar-Ola	VSUT
Serbia	Belgrade	Univ.
Slovakia	Bratislava	CU
		IP SAS
	Košice	IEP SAS
Spain	Santiago de Compostela	USC
	Valencia	UV
Switzerland	Bern	Uni Bern
	Villigen	PSI
Sweden	Lund	LU
United Kingdom	London	QM
		Imperial College
	Canterbury	Univ.
Ukraine	Kiev	BITP NASU
	Dnepropetrovsk	DNU
	Kharkov	KFTI
	Lutsk	VNU
	L'viv	IAPMM NASU

		IFNU
		SumSU
USA	Suny New York, NY	RU
		CUNY
	College Park, MD	UMD
	Lemont, IL	ANL
	Minneapolis, MN	U of M
	Norman, OK	OU
	Newport News, VA	JLab
	Philadelphia, PA	Penn
	University Park, PA	Penn State
Uzbekistan	Tashkent	IAP NUU
		NUU
Vietnam	Hanoi	IOP VAST

## Theory of Nuclear Structure and Nuclear Reactions

### Leaders:

V.V. Voronov  
A.I. Vdovin  
N.V. Antonenko

### Participating Countries and International Organizations:

Armenia, Austria, Belarus, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Egypt, France, Germany, Greece, Hungary, Italy, Japan, Kazakhstan, Moldova, Norway, Poland, Republic of Korea, Romania, Russia, Serbia, Slovakia, South Africa, Spain, Sweden, Switzerland, Taiwan, Ukraine, USA, Uzbekistan.

### Scientific Programme

The main goals are to predict and analyze properties of atomic nuclei beyond the stability valley and investigate structure peculiarities of superheavy and exotic nuclei; to study dynamics of nuclear collisions at low and intermediate energies accompanied by production of stable as well as radioactive nuclides; to investigate fundamental properties of various few-body systems and develop rigorous and effective mathematical methods of calculations of their properties; to explore the dynamics of particle-nucleus and nucleus-nucleus collisions at relativistic energies and nuclear matter properties and its phase transitions at extreme values of temperature and density.

#### Expected main results in 2017:

- Investigation of the impact of the phonon-phonon coupling on the beta-delayed multi-neutron emission of neutron-rich nuclei.
  - Study of the effects of the quasiparticle-phonon interaction on the E1-strength in neutron-rich Ca isotopes.
  - Analysis of the influence of the fourth order Wigner function moments on the energies and excitation probabilities of nuclear collective states.
  - Elaboration of the effective method to study the impact of deformation on the beta-decay half-lives and delayed multi-neutron emission probabilities.
  - Study of the possibility to identify the toroidal E1 resonance for the anomalous deformation splitting.
- Calculations of the energies of the lowest quadrupole states of the even-even superheavy nuclei applying the Grodzins relation.
  - Determination of the probability to observe the collinear separation of true ternary fission fragments at spontaneous fission of  $^{252}\text{Cf}$  and in the  $^{235}\text{U}(n,f)$  reaction.
  - Assessment of the prospects of the SHE production in charged particle evaporation channels.
  - Theoretical search for fissionable actinide isotopes, in which the charge distribution of the fission products remains asymmetrical even at a rather high excitation energy.
  - Evaluation of the probabilities to product new actinide isotopes in the multi-nucleon transfer reactions and the search most efficient reactions to this end.
  - Calculation the probability to synthesize new actinide isotopes in the multi-nucleon transfer reactions aiming to determine the most effective reactions for their production.
  - Application of the non-Markovian Langevin approach to study the dynamics of fermionic (bosonic) subsystem, linearly coupled to the fermionic (bosonic) environment.
- Determination of conditions for emerging the confinement-induced resonances in hybrid atom-ion systems.
  - Determination of the solvability conditions for the operator Riccati equation associated with a  $2 \times 2$ -block-matrix Hamiltonian in the three-gap spectral case.
  - Development of a dynamic approach to the study of the ionization processes in atomic collisions.

Calculation of binding energies and scattering observables as well as the study of the Efimov properties of van-der Waals clusters  $\text{LiHe}_2$  applying the hard-core differential Faddeev equations.

Study of the Coulomb breakup of exotic nuclei in the non-stationary quantum-mechanical approach.

Calculation of electron scattering off hydrogen molecule and hydrogen molecular ion in the kinematic regime of laser-assisted electron momentum spectroscopy.

- Calculations of excitation functions for the first three cumulants of hadronic distributions within the PHSD model for relativistic Au+Au collisions including the NICA energy and aiming to search for signals of a possible quark-hadron phase transition.

Study of the properties of nuclear interactions in the presence of strong electromagnetic fields under conditions of violation of the CP invariance of strong interactions. The behavior of masses and couplings for quarks, diquarks and mesons will be studied at finite temperature and density.

Investigation of non-linear quantum processes in strong linearly-polarized electromagnetic fields and subsequent generalization of the theory to the electromagnetic fields induced in relativistic heavy-ion collisions.

Elaboration of the theoretical approach to analyse open charm production in a pion and anti-proton induced reaction and investigation of the structure of charmed resonances.

Development of the folding model of a meson-nuclear potential and analysis of the corresponding experimental data.

## List of activities:

<b>Activity or experiment</b>	<b>Leaders</b>
<b>Laboratory or other</b>	<b>Main researchers</b>
<b>Division of JINR</b>	
<b>1. Nuclear properties</b>	<b>V.V. Voronov</b>
<b>at the border of stability</b>	<b>A.A. Dzhioev</b>
	<b>J. Kvasil</b>
BLTP	N.N. Arseniev, E.B. Balbutsev, A.I. Vdovin, V.A. Kuz'min, L.A. Malov, S. Mishev, V.O. Nesterenko, A.P. Severyukhin, H. Ganev, V.M. Shilov, A.V. Sushkov, E.O. Sushenok, + 3 students
LIT	N.Yu. Shirikova, I.V. Molodtsova
FLNP	A.M. Sukhovoi
DLNP	V.B. Brudanin, V.G. Kalinnikov
<b>2. Low-energy dynamics</b>	<b>S.N. Ershov</b>
<b>and nuclear system properties</b>	<b>N.V. Antonenko</b>
	<b>R.V. Jolos</b>
BLTP	G.G. Adamian, A.V. Andreev, A.N. Bezbakh, I.A. Egorova, S.I. Fedotov, V.G. Kartavenko, Sh. Kalandarov, A.K. Nasirov, R.G. Nazmitdinov, H. Paska, T.M. Shneidman, + 1 students
FLNR	L.V. Grigorenko, Yu.E. Penionzhkevich
<b>3. Quantum few-body systems</b>	<b>A.K. Motovilov</b>
	<b>A.S. Melezhik</b>
BLTP	S.S. Kamalov, O.P. Klimenko, E.A. Kolganova, A.A. Korobitsyn, O.A. Koval, E.A. Koval, A.V. Malykh, V.S. Melezhik, V.N. Kondratyev, V.V. Pupyshev, E.A. Soloviev, S.I. Vinitsky, P. Jaluvkova, + 4 students



DLNP

O.I. Kartavtsev

**4. Processes with nuclei  
at relativistic energies  
and extreme states of matter**

**V.V. Burov  
M. Gaidarov**

BLTP

A. Bekzhanov, S.G. Bondarenko, A.V. Frisen, L.P. Kaptari,  
A. Khvorostukhin, V.K. Lukyanov, A.S. Parvan,  
N. Sagimbaeva, A.I. Titov, V.D. Toneev, + 1 students

LIT

E.B. Zemlianaya, K.V. Lukyanov

VBLHEP

A.I. Malakhov, N.M. Piskunov, Yu.A. Panebratsev,  
E.P. Rogochaya

**Collaboration**

**Country or International  
Organization**

**City**

**Institute or Laboratory**

Armenia

Yerevan

RAU

Austria

Innsbruck

Univ.

Belarus

Minsk

IP NASB

Belgium

Brussels

VUB

Louvain-la-Neuve

UCL

Brazil

Florianopolis, SC

UFSC

Sao Paulo, SP

UEP

Sao Jose dos Campos, SP

ITA

Niteroi, RJ

UFF

Bulgaria

Sofia

INRNE BAS

NBU

Canada

Hamilton

McMaster

Saskatoon

U of S

China

Beijing

ITP CAS

CIAE

PKU

Czech Republic

Prague

CU

Řež

NPI ASCR

Egypt

Cairo

EAEA

Giza

CU

France

Bordeaux

UB

Caen

GANIL

Orsay

CSNSM

IPN Orsay

Germany

Bonn

UniBonn

Cologne

Univ.

Darmstadt

GSI

IKP

TU Darmstadt

Dresden

HZDR

Erlangen

FAU

	Frankfurt/Main	Univ.
	Hamburg	Univ.
	Giessen	JLU
	Leipzig	UoC
	Mainz	JGU
	Regensburg	UR
	Rostock	Univ.
	Siegen	Univ.
Greece	Thessaloniki	AUTH
	Athens	INP NCSR "Demokritos"
Hungary	Budapest	Wigner RCP
	Debrecen	Atomki
Italy	Bologna	Centro, ENEA
	Catania	INFN LNS
	Naples	INFN
	Messina	UniMe
	Perugia	INFN
	Trento	ECT*
	Turin	UniTo
Japan	Kobe	Kobe Univ.
	Morioka	Iwate Univ.
	Osaka	RCNP Osaka Univ.
Kazakhstan	Almaty	INP KazNU
Moldova	Chişinău	IAP ASM
Norway	Bergen	UiB
	Oslo	UiO
Poland	Krakow	NINP PAS
	Lublin	UMCS
	Otwock-Swierk	NCBJ
	Warsaw	UW WUT
Republic of Korea	Seoul	SNU
	Daejeon	IBS
Romania	Bucharest	IFIN-HH UB
Russia	Moscow	NNRU "MEPhI" MSU NRC KI SINP MSU
	Moscow, Troitsk	INR RAS
	Gatchina	PNPI
	Irkutsk	ISU

	Omsk	OmSU
	Saratov	SSU
	St. Petersburg	SPbSU
	Vladivostok	FEFU
Serbia	Belgrade	IPB
Slovakia	Bratislava	CU
		IP SAS
South Africa	Pretoria	Unisa
	Stellenbosch	SU
	Cape Town	iThemba LABS
Spain	Palma	UIB
Sweden	Lund	LU
	Göteborg	Chalmers
Switzerland	Bern	Uni Bern
Taiwan	Taipei	NTU
Ukraine	Kiev	KINR NASU
		BITP NASU
USA	Lemont, IL	ANL
	Los Alamos, NM	LANL
	Notre Dame, IN	ND
	University Park, PA	Penn State
Uzbekistan	Tashkent	IAP NUU
		INP AS RUz
		Assoc.“P.-S.” PTI

## Theory of Condensed Matter

### Leaders:

V.A. Osipov  
A.M. Povolotskii

### Participating Countries and International Organizations:

Armenia, Australia, Austria, Belarus, Belgium, Brazil, Bulgaria, Canada, Czech Republic, France, Germany, Hungary, India, Ireland, Italy, Japan, Moldova, Mongolia, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Switzerland, Taiwan, Ukraine, USA, Uzbekistan, Vietnam.

### Scientific Programme

Effects of strong electron correlations in high-temperature superconductors, colossal magneto-resistance compounds (manganites), heavy-fermion systems, low-dimensional quantum magnets with strong spin-orbit interaction, topological insulators, etc. will be investigated based on a variety of underlying many-band electronic models including the extended Hubbard model, Anderson model, super-exchange spin-orbital models of transition of metal oxides with strong relativistic spin-orbital coupling. The electronic band structure, spectral properties of charge carrier quasiparticles, magnetic and charge collective excitations, metal-insulator and magnetic phase transitions, Cu- and Fe-based high-Tc superconductivity, charge and spin-orbital ordering will be studied. The obtained results will be used to support neutron scattering experiments performed at FLNP, JINR.

Investigations in the field of nanostructures and nanoscaled phenomena will be addressed to a study of physical characteristics of nanomaterials promising for various applications in modern nanotechnologies. The electronic, thermal and transport properties of carbon nanostructures will be investigated. It is planned to study the problem of quantum transport in molecular devices. Spin dynamics of magnetic nanoclusters will be investigated. The analysis of resonance tunneling phenomena in the layered superconductors and superconducting nanostructures in the external fields will be performed. Numerical modeling of resonance, radiative and chaotic properties of intrinsic Josephson junctions in high temperature superconductors is planned to be carried out.

Models in condensed matter physics will be studied by using methods of equilibrium and non-equilibrium statistical mechanics with the aim of revealing general properties of many-particle systems based on the ideas of self-similarity and universality. Mathematical mechanisms, underlying the kinetic and stationary behavior of model systems, as well as possible links between different models, will be investigated. The study of two-dimensional lattice models by the transfer matrix method will be focused on confirming the predictions of the logarithmic conformal field theory. The theory of integrable systems will be developed in the aspect of finding new integrable boundary conditions for two-dimensional spin systems and the solution of the corresponding Yang-Baxter equations. The universal behavior of correlation functions in non-equilibrium systems will be studied as well. The research in the structure theory and the theory of representations of quantum groups and matrix algebras will be directed to further applications in the theory of integrable models in quantum mechanics and statistical physics. Applications of the elliptic hypergeometric integrals, defining the most general solutions of the Yang-Baxter equation and most complicated known exactly computable path integrals in four-dimensional quantum field theory, to two-dimensional spin systems will be studied.

### Expected main results in 2017:

- Theoretical study of electronic and magnetic properties of strongly correlated systems including newly synthesized oxides 3d, 4d and 5d transition metals.

Theoretical study of electronic, transport and optical properties of hybrid perovskites for the third generation of solar cells.

Calculation of the spin-wave excitation spectrum, magnetization, susceptibility and the Neel temperature for the quasi-two-dimensional Kitaev-Heisenberg model on the honeycomb lattice proposed for iridates in the antiferromagnetic and paramagnetic states.

Development of the superconducting theory for the quasi-two-dimensional compass- Heisenberg model and the Kitaev-Heisenberg model on the honeycomb lattice.

Investigation of the one-dimensional Bose gas in external potentials. Description of short-range correlations in the Bose gas in the regime of strong interactions.

Development of theoretical models for small-angle scattering from mass and surface fractals. Theoretical study of small-angle scattering from multifractals.

Investigation of generation of magnetic precession by Josephson current in the presence of spin-orbital coupling in the external electromagnetic field. The classification of the appearing superconducting spintronics effects.

Study of the hopping mechanism of the vibron excitation transport in macromolecular chains in the framework of non-adiabatic polaron theory depending on the quantum state of the macromolecular structural elements, such as squeezed and chaotic squeezed states.

Theoretical investigation of the electron conductivity in polycrystalline graphene. Calculation of a relaxation time due to a finite charged dislocation wall of a different type (grain boundary scattering), and the corresponding contribution to the tensor of conductivity as a function of temperature and carriers concentration.

Application of the extended self-consistent Huckkel method, along with the non-equilibrium Green's function method and finding of the current-voltage characteristics of some graphene nanostructures. Investigation of the influence of the phonon-phonon interaction to the thermal conductance of the graphene nanoribbons with a different width.

Development of the new concepts of electronic nano-devices based on graphene and graphene ribbons. Investigation of different aspects of electron transport in the electronic devices based on the graphene edge states.

Within the dual model of strongly correlated electrons, the spin correlation function is to be computed for the lightly doped cuprates beyond the mean-field approximation.

- Construction of superconformal indices for quiver supersymmetric gauge theories and description of their relation to partition functions of lattice spin systems.

Consideration of a traffic model, where a condition of irreversible aggregation is introduced along with the standard conditions of the excluded volume. Irreversible aggregation means that a cluster of particles being emerged once will not be destroyed later and all particles of the cluster move synchronously. The model is defined on a finite interval with a given ingoing and outgoing probabilities  $\alpha$ ,  $\beta$  at the ends of interval. The phase diagram of the stationary state will be constructed and its peculiarities in four different sectors will be explained.

Detailed investigation of the rotor-router aggregation model on infinite graphs.

Investigation of separation of variables in three-body elliptic Calogero-Moser systems.

Computation of large-deviation probabilities in the spherical model, generalized spherical model and in the models of the Boson gas.

Investigation of the structure of quantum matrix algebras of orthogonal and symplectic types, classification of irreducible representations of the braid group  $B_3$  in low dimensions.

Solving of spectral problems in systems of mixed dimensionality. Derivation of new characteristics of the equiangular tight frames.

Description of the transition from the Kardar-Parisi-Zhang regime to the deterministic aggregation regime in the non-stationary fluctuations of particle current in the model of generalized asymmetric simple exclusion process. Calculation of the universal finite size corrections to the large deviation function of particle current in the model of random walks in a random environment.

Development of the theory of Bose-condensed systems with dipolar interaction potentials.

Formulation of an approach for describing non-equilibrium networks of complex quantum systems.

Study of the time evolution and stationary states of open many-particle interacting systems by means of a special procedure of a reduced description. The method of maximum information entropy will be analyzed in this context.

Construction of solutions of the Yang-Mills equations on conical spaces with Lorentzian metric in various dimensions. Study of the particle-vortex duality.

## List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers
<b>1. Complex materials and nanostructures</b>	<b>V.A. Osipov N.M. Plakida</b>
BLTP	E.M. Anitas, A.Yu. Cherny, A.V. Chizhov, V. Ilkovich, O.G. Isaeva, V.L. Katkov, E.A. Kochetov, D.V. Kolesnikov, S.E. Krasavin, D.A. Lobanov, M. Maiti, A.N. Novikov, V.N. Plechko, I.R. Rahmonov, J. Schmelzer, Yu.M. Shukrinov, M.A. Smondyrev, J. Smotlacha, A.A. Vladimirov, V.Yu. Yushankhai
FLNP	V.L. Aksenov, A.M. Balagurov, A.I. Kuklin
LIT	E.B. Zemlianaya, I. Sarhadov, S.I. Serdyukova, L.A. Syurakhshina
<b>2. Contemporary problems of statistical physics</b>	<b>A.M. Povolotsky V.B. Priezzhev</b>
BLTP	J. Brankov, N.Zh. Bunzarova, V.M. Dubovik, V.I. Inozemtsev, A.L. Kuzemsky, T.A. Ivanova, V. Papoyan, A.E. Patrik, P.N. Pyatov, V.P. Spiridonov, O. Turek, V.I. Yukalov, P.E. Zhidkov
LIT	E.P. Yukalova

## Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL
Australia	Melbourne	Univ.
	Sydney	Univ.
Austria	Vienna	TU Wien
Belarus	Minsk	BSTU IP NASB ICE MES RB JIPNR-Sosny NASB
Belgium	Louvain-la-Neuve	UCL
Brazil	Brasilia, DF	UnB
	Sao Paulo, SP	USP
	Natal, RN	IIP UFRN
Bulgaria	Sofia	IMEch BAS ISSP BAS SU INRNE BAS
Canada	Montreal	Concordia
	Quebec	UL
	Kingston	Queen's

Czech Republic	London	Western
France	Řež	NPI ASCR
	Annecy-le-Vieux	LAPTh
	Paris	UPMC
	Marseille	CPT
		UPC
	Nice	UN
	Valenciennes	UVHC
Germany	Bonn	UniBonn
	Bremen	Univ.
	Braunschweig	TU
	Dortmund	TU Dortmund
	Darmstadt	GSI
	Dresden	IFW
		MPI PkS
		TU Dresden
	Duisburg	UDE
	Leipzig	UoC
	Magdeburg	OVGU
	Rostock	Univ.
	Stuttgart	MPI-FKF
	Wuppertal	UW
Hungary	Budapest	Wigner RCP
India	Mumbai	TIFR
Ireland	Dublin	DIAS
Italy	Catania	UniCT
	Salerno	UNISA
Japan	Kochi	KUT
Poland	Krakow	JU
	Warsaw	IPC PAS
		WUT
	Katowice	US
	Poznan	AMU
		IMP PAS
Romania	Bucharest	IFIN-HH
	Cluj-Napoca	UTC-N
	Timișoara	UVT
Russia	Moscow	MIREA
		NNRU "MEPhI"
		NRU HSE
		PFUR
		SINP MSU
		MI RAS
		NRC KI
	Moscow, Troitsk	HPPI RAS

	Belgorod	BelSU
	Gatchina	PNPI
	Kazan	KFU
	Krasnoyarsk	KIP SB RAS
	Protvino	IHEP
	Saratov	SSU
	St. Petersburg	ETU
		IPTI RAS
		SPbSU
		PDMI RAS
		VSU
Moldova	Voronezh	IAP ASM
Mongolia	Chişinău	NUM
Serbia	Ulaanbaatar	INS "VINČA"
Slovakia	Belgrade	CU
	Bratislava	IEP SAS
	Košice	TUKE
Slovenia	Ljubljana	UL
Spain	Madrid	ICMM-CSIC
Switzerland	Villigen	PSI
	Zurich	ETH
Taiwan	Taipei	IP AS
Ukraine	Kharkov	KFTI
	Kiev	IMP NASU
		NUK
	L'viv	ICMP NASU
USA	Louisville, KY	UofL
	New York, NY	CUNY
	Rochester, NY	UR
	Tallahassee, FL	FSU
Uzbekistan	Tashkent	Assoc."P.-S." PTI
Vietnam	Hanoi	IMS VAST



## Modern Mathematical Physics: Strings and Gravity, Supersymmetry, Integrability

**Leaders:** A.P. Isaev  
A.S. Sorin  
**Deputy:** S.O. Krivonos  
**Scientific leader:** A.T. Filippov

### Participating Countries and International Organizations:

Australia, Austria, Armenia, Belarus, Brazil, Bulgaria, Canada, CERN, Czech Republic, France, Germany, Greece, Hungary, ICTP, India, Italy, Japan, Norway, Poland, Romania, Russia, Serbia, Spain, Turkey, Ukraine, United Kingdom, USA.

### Scientific Programme

The main purpose of research in modern mathematical physics is the development of mathematical methods for solving the most important problems of modern theoretical physics: clarifying the nature of fundamental interactions and their symmetries, construction and study of effective field models arising in the theory of strings and other extended objects, uncovering the geometric description of quantum symmetries and their spontaneous breaking in the framework of search for a unified theory of all fundamental interactions, including quantum gravity. Mathematical physics in recent years has been characterized by increasing interest in identifying and effective use of integrability in various areas, and in applying powerful mathematical methods of quantum groups, supersymmetry and non-commutative geometry to quantum theories of fundamental interactions as well as to classical models.

The main goals and tasks of the research within the theme include: development of new mathematical methods for description of a variety of integrable models and their exact classical and quantum solutions; analysis of a wide range of problems in the theory of superstrings and superbranes, including study of nonperturbative regimes in supersymmetric gauge theories; development of a microscopic description of black holes and constructing cosmological models of the early Universe. The decisive factor to solve the above problems is a crucial use of the mathematical methods of the theory of integrable systems, quantum groups and noncommutative geometry as well as superspace techniques.

### Expected main results in 2017:

- Construction of supergravity backgrounds which describe intersecting D-(M)-brane solutions with Lifshitz-like asymptotics. Analysis of the obtained solutions in the framework of the gauge/gravity duality. Investigation of correlation functions between a Wilson loop and local photons in the obtained backgrounds using the holographic approach.

Construction and analysis of solutions without a horizon (boson stars) with Lifshitz-like asymptotics. Construction of Kerr-Vaidya/ Kerr-Newman-Vaidya solutions with AdS asymptotics for D=5 supergravity model. Study of local operators (two-point correlation functions) for the constructed metrics via holography.

Study of systems with one-half spontaneously broken supersymmetry and construction of the component action for the Born-Infeld theory with N=4, d=4 supersymmetry, with N=2 vector multiplet as Goldstone superfield.

Construction of the supersymmetric extensions of the mechanics, including the Pais-Uhlenbeck oscillator with specific frequencies, which are invariant with respect to the l-conformal Galilei group or its deformations.

Calculation of the monodromy matrix elements action onto universal Bethe vectors in the quantum integrable models associated with supersymmetric extension of the Yangian double. Application of these formulas for obtaining a supersymmetric analog of the Reshetikhin's formula for the scalar products of the Bethe vectors in the supersymmetric models.

Study of the universal Bethe vectors for the quantum integrable models associated with  $gl(4)$  and  $gl(2,2)$  spin chains. Study of the representations of connected Yangians with the aim to obtain the correlation functions in quantum integrable models.

In the framework of special Bohr–Sommerfeld geometry, applications to the case when the phase space is not simply connected will be studied. Investigation of a relation between special Bohr–Sommerfeld geometry and the Hitchin integrable systems in the simplest case of riemannian surfaces of genus  $> 1$ .

Construction of moduli spaces of special Bohr–Sommerfeld cycles in the algebraic case. It will be shown that in the algebraic case these moduli spaces are finite dimensional.

- The  $N = (1; 1)$ ; 6D SYM superfield invariants including the candidate counterterms found earlier from the pure symmetry considerations will be reproduced from the full-fledged quantum perturbation theory in  $N = (1; 1)$  and  $N = (1; 0)$  harmonic superspaces. The background field method for  $N = (1; 1)$ ; 6D SYM theory will be developed in full generality.

Construction and study of the  $SU(2|1)$  and  $SU(2|2)$  invariant extensions of the Calogero-Moser models as deformations of  $N = 4$  supersymmetric extensions.

The models of  $N = 4$  supersymmetric quantum mechanics with “long multiplets”, as well as their  $SU(2|1)$  deformations, will be thoroughly studied, their bosonic target geometry will be revealed and quantum spectrum will be found for a few particular cases.

The study of 6D supergravity models in the off-shell  $N = (1; 0)$  and on-shell  $N = (1; 1)$  6D harmonic superspaces will be started. The constraints of  $N = (1; 1)$  6D supergravity will be solved in terms of  $N = (1; 0)$  superfields.

Construction of superfield action for the many-particle systems with  $N=4$  deformed supersymmetry. Superfield formulation of sigma model with Wess-Zumino term possessing the  $N=4$  deformed supersymmetry and describing the interaction of the spinning particle with an external gauge background.

Construction of models for spinning particles and superparticles using momentum twistors. Obtaining of transition amplitudes from the BFV–BRST path integral.

Definition of geometries described by  $N=4$  supersymmetric quantum mechanical sigma models with a variety of dynamical, semi-dynamical and gauge supermultiplets. Determination of the type of supercharges for different geometries.

Construction of new hairy black holes linked to charged scalar clouds in the Kerr-Newman space-time. Investigation of the near BPS spinning self-gravitating Skyrmons. Construction of spinning black holes with the BPS Skyrme hair.

- Observations of bright stars near the Galactic Center will be used for obtaining constraints on modification of the Newton gravity law in the weak field approximation. The bounds on a graviton mass will be obtained also proceeding from a potential reconstruction at the Galactic Center.

Realistic inflation scenarios consistent with observational data from Planck-2015 will be developed by making use of the classical Yang-Mills fields non-minimally coupled to gravity.

Description of the scalar-tensor perturbations in modified theories of gravity without the Einstein frame; in particular, in theories with an arbitrary function of the torsion scalar.

The stability of modified gravity theories with higher derivatives will be studied regarding different perturbations.

The explicit compact formulae are expected to be derived for the forces exerted on the material medium by the electromagnetic field, taking advantage of the different forms for the relevant energy-momentum tensor.

Derivation of the vacuum energy of quantized fields in the presence of crossed cosmic strings and extraction of its finite part depending on the strings’ mutual position.

Study of the vacuum fluctuations on the lattice background formed by multi-dimensional delta functions.

Construction of integrable scalar cosmologies with a cubic integral of motion.

## List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers
<b>1. Quantum groups and integrable systems</b>	<b>A.P. Isaev</b>
BLTP	S.A. Belev, A.A. Golubtsova, I. Bormotova, S.O. Krivonos, N.Yu. Kozyrev, R.M. Mir-Kasimov, S.Z. Pakulyak, G.S. Pogosyan, N.A. Tyurin, + 4 students
<b>2. Supersymmetry</b>	<b>E.A. Ivanov</b>
BLTP	S.A. Fedoruk, M. Pientek, S.S. Sidorov, Ya.M. Shnir, A.Pietrikovsky, A.Rivasplata A.O. Sutulin, + 2 students
<b>3. Quantum gravity, cosmology and strings</b>	<b>A.T. Filippov V.V. Nesterenko A.S. Sorin</b>
BLTP	B.M. Barbashov, E.A. Davydov, D.V. Fursaev, A.B. Pestov, I.G. Pirozhenko, A.D. Popov, E.A. Tagirov, P.V. Tretyakov, + 3 students
LIT	I.L. Bogoliubsky, A.M. Chervyakov
VBLHEP	E.E. Donets
UC	S.Z. Pakuliak

## Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	YSU
Australia	Sydney	Univ.
	Crawley	UWA
Austria	Vienna	TU Wien
Belarus	Minsk	IP NASB BSU
Brazil	Sao Paulo, SP	USP
	Juiz de Fora, MG	UFJF
Bulgaria	Sofia	INRNE BAS SU
Canada	Montreal	McGill UdeM
	Edmonton	U of A
CERN	Geneva	CERN
Czech Republic	Opava	SIU
	Prague	CTU CU
	Řež	NPI ASCR
France	Annecy-le-Vieux	LAPP

		LAPTh
	Dijon	UB
	Lyon	ENS Lyon
	Marseille	CPT
	Nantes	SUBATECH
	Paris	ENS
		LUTH
		LPTHE
	Palaiseau	Polytech
	Valenciennes	UVHC
Germany	Berlin	FU Berlin
		HUB
		MBI
	Bielefeld	Univ.
	Bonn	UniBonn
	Dortmund	TU Dortmund
	Hannover	LUH
	Jena	Univ.
	Leipzig	UoC
	Munich	MPI-P
	Oldenburg	IPO
	Potsdam	AEI
Greece	Athens	UoA
Hungary	Budapest	Wigner RCP
India	Calcutta	BNC
Italy	Bari	INFN
	Frascati	INFN LNF
	Naples	INFN
	Padua	UniPd
	Pavia	INFN
	Pisa	INFN
	Salerno	UNISA
	Trieste	SISSA/ISAS
	Turin	INFN
ICTP	Trieste	ICTP
Japan	Fukuoka	Kyushu Univ.
	Kyoto	KSU
		RIMS
		YITP
	Tsukuba	KEK
Norway	Trondheim	NTNU
Poland	Warsaw	NCAC PAS
		UW
	Krakow	JU
		NINP PAS

	Lodz	UL
	Wroclaw	UW
Romania	Bucharest	IFIN-HH
Russia	Moscow	ITEP
		LPI RAS
		MSU
		MI RAS
		NRU HSE
		VNIIMS
	Moscow, Troitsk	INR RAS
	Chernogolovka	LITP RAS
	Protvino	IHEP
	St. Petersburg	PDMI RAS
		SPbSU
	Tomsk	TPU
Serbia	Belgrade	IPB
		Univ.
Spain	Bilbao	UPV/EHU
	Barcelona	IEEC-CSIC
	Valencia	IFIC
Turkey	Istanbul	BU
	Izmir	IZTECH
USA	New York, NY	CUNY
		RU
		SUNY
	Baltimore, MD	JHU
	Cincinnati, OH	UC
	College Park, MD	UMD
	Coral Gables, FL	UM
	Minneapolis, MN	U of M
	Norman, OK	OU
	Philadelphia, PA	Penn
	Piscataway, NJ	Rutgers
	Rochester, NY	UR
Ukraine	Kiev	BITP NASU
	Kharkov	KFTI
United Kingdom	London	Imperial College
	Cambridge	Univ.
	Durham	Univ.
	Liverpool	Univ.
	Southampton	Univ.
	York	Univ.

## Dubna International Advanced School of Theoretical Physics (DIAS-TH)

### Leaders:

A.S. Sorin  
V.V. Voronov

### Participating Countries and International Organizations:

Austria, Brazil, Bulgaria, Canada, CERN, Czech Republic, France, Germany, Greece, Hungary, India, Israel, Italy, Japan, Mexico, Poland, Romania, RSA, Russia, Serbia, Turkey, Ukraine, United Kingdom, USA, Vietnam.

The Bogoliubov Laboratory of Theoretical Physics (BLTP) has a good record of organizing international workshops and schools in Dubna. DIAS-TH organizes and supervises all educational programs for students, postgraduates, and young scientists at BLTP. It should function continuously and the standard short schools (about 3-4 a year) should be organized coherently. Other educational programs in Dubna such as the JINR University Center may also correlate with DIAS-TH (common programs on modern theoretical physics, workshops for students and young scientists, etc.).

### The main goals of DIAS:

- Training courses for students, graduates, and young scientists in the JINR Member States and other countries (according to special agreements and grants).
- Looking for and supporting gifted young theorists in the JINR Member States; creating databases of students and young researchers.
- Organization of schools of different levels in Dubna and coordination with similar schools in Russia, Germany, and other European countries.
- Support of the JINR experimental programs by organizing lecture courses and review lectures on new trends in modern physics.
- Cooperation with the JINR University Center in training students and postgraduates as well as in organizing schools for students.
- Coordination of the research - training programs with workshops and conferences at JINR.
- Publication of lectures and discussions in different forms, in particular, with the use of modern electronic equipment, etc.
- Supporting the WEB page of DIAS-TH which should become the organizing center of the programs related to DIAS-TH.

The main topics of the DIAS activity should be centered around the most important directions of research at BLTP: Theory of Fundamental Interactions; Nuclear Theory; Theory of Condensed Matter; Modern Mathematical Physics.

### Expected main results in 2017:

- Organization of three international schools at BLTP.
- Organization of one-day lectures/discussions and regular seminars for students and post-graduates.
- Computer processing of video records of lectures, support of digital archive of video records.
- Support of Web-site of DIAS-TH.

**List of activities:**

<b>Activity or experiment</b>	<b>Leaders</b>
<b>Laboratory or other</b>	<b>Main researchers</b>
<b>Division of JINR</b>	
1. DIAS-TH	<b>A.S. Sorin</b> <b>V.V. Voronov</b>
BLTP	D. Blaschke, A.T. Filippov, A.P. Isaev, E.A. Kolganova, R.V. Jolos, I.G. Pirozhenko, O.V. Teryaev, P.V. Tretyakov, A.A. Starobinsky, V.I. Zhuravlev + 4 students
LIT	V.V. Korenkov
UC	S.Z. Pakuliak
FLNP	V.L. Aksenov
VBLHEP	I.A. Savin, Yu.A. Panebratsev
DLNP	V.A. Bednyakov
FLNR	Yu.Ts. Oganessian

**Collaboration**

<b>Country or International</b>	<b>City</b>	<b>Institute or Laboratory</b>
<b>Organization</b>		
Austria	Vienna	Univ. TU Wien
Brazil	Sao Paulo, SP	USP
Bulgaria	Sofia	INRNE BAS SU
Canada	Montreal	UdeM
	Edmonton	U of A
CERN	Geneva	CERN
Czech Republic	Prague	CTU IP ASCR NPI ASCR
	Řež	
France	Annecy-le-Vieux	LAPP
	Dijon	UB
	Lyon	ENS Lyon
	Marseille	CPT
	Nantes	SUBATECH
	Paris	ENS LPTHE UPMC
	Valenciennes	UVHC
Germany	Bonn	UniBonn
	Frankfurt/Main	Univ.
	Hamburg	DESY
	Hannover	LUH

	Jena	Univ.
	Leipzig	UoC
	Munich	MPI-P
	Potsdam	AEI
	Rostock	Univ.
	Zeuthen	DESY
Greece	Athens	UoA
Hungary	Budapest	Wigner RCP
India	Calcutta	BNC
Italy	Frascati	INFN LNF
	Padua	UniPd
	Pavia	INFN
	Pisa	INFN
	Salerno	UNISA
	Trieste	SISSA/ISAS
	Turin	INFN
Israel	Rehovot	WIS
Japan	Kyoto	KSU
		RIMS
	Tsukuba	KEK
Mexico	Leon	UG
Poland	Warsaw	UW
	Otwock-Swierk	NCBJ
	Wroclaw	UW
Romania	Bucharest	IFIN-HH
South Africa	Cape Town	UCT
Russia	Moscow	ITEP
		LPI RAS
		MSU
		SCC RAS
		SINP MSU
		MI RAS
		VNIIMS
	Moscow, Troitsk	INR RAS
	Chernogolovka	LITP RAS
	Gatchina	PNPI
	Petrozavodsk	PetrSU
	Protvino	IHEP
	St. Petersburg	PDMI RAS
	Tomsk	TSU
Serbia	Belgrade	IPB
		Univ.
Turkey	Istanbul	BU
Ukraine	Kiev	BITP NASU
United Kingdom	London	Imperial College



	Durham	Univ.
	Cambridge	Univ.
	Southampton	Univ.
	York	Univ.
USA	New York, NY	CUNY
		SUNY
	Baltimore, MD	JHU
	College Park, MD	UMD
	Cincinnati, OH	UC
	Coral Gables, FL	UM
	Minneapolis, MN	U of M
	Newport News, VA	JLab
	Philadelphia, PA	Penn
	Piscataway, NJ	Rutgers
	Rochester, NY	UR
	Salt Lake City, UT	U of U
Vietnam	Hanoi	IOP VAST



Elementary  
Particle Physics  
and  
Relativistic  
Nuclear Physics  
(02)

02-2-1123-2015/2019

Priority:

1

Status:

Extended

## JINR's Participation at the BES-III Physics Research Program

**Leader:** A.S. Zhemchugov

### Participating Countries and International Organizations:

China, Russia.

### Scientific Programme

The BES-III experiment at the electron-positron collider BEPC (IHEP CAS, Beijing, China) is aimed at systematic and precise measurements in  $\tau$ -charm domain. The main goals of the experiment include light hadron spectroscopy, study of charmonium spectrum and transitions, study of open charm particles like D and Ds mesons,  $\tau$ -lepton physics and search for new exotic XYZ states. Data taking started in 2009. The world largest sample of  $J/\psi$ ,  $\psi(3686)$ ,  $\psi(3770)$ ,  $\psi(4040)$  is already collected. Scan in the energy range 2.0–4.6 GeV is performed for R-ratio measurement. Unique sample in the energy range 4.2–4.6 GeV is collected to search for new XYZ states.

#### Expected main results in 2017:

- BES-III data analysis.
- Development of offline software and analysis tools
- Development of the distributed computing system (integration of cloud resource).
- Development of high-performance PWA software using HybriLIT cluster.

### List of projects:

Project	Leader	Priority (period of realization)
1. BES-III	A.S. Zhemchugov	1 (2007 – 2019)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
BES-III Project	A.S. Zhemchugov	Realization
DLNP	I.R. Boyko, A.V. Guskov, D.V. Dedovich, Yu.A. Nefedov, G.A. Shelkov, I.I. Denisenko, E.A. Boger, O.V. Bakina, E. Tskhadadze, V.A. Tokareva	
BLTP	V.V. Bytev, O.V. Teryaev	
LIT	V.V. Korenkov, A.V. Uzhinsky, S.D. Belov, I.S. Pelevanyuk, V.V. Trofimov, O.I. Streltsova, D.V. Podgainy	

## **Collaboration**

**Country or International  
Organization**

China  
Russia

**City**

Beijing  
Gatchina  
Novosibirsk

**Institute or Laboratory**

IHEP CAS  
PNPI  
BINP SB RAS

## ATLAS.

### Upgrade of the ATLAS Detector and Physics Research at the LHC

**Leader:** V.A. Bednyakov  
**Deputies:** E.V. Khramov  
 A.P. Cheplakov

#### Participating Countries and International Organizations:

Armenia, Azerbaijan, Belarus, Canada, CERN, Czech Republic, France, Germany, Georgia, Greece, Israel, Italy, Netherlands, Russia, Slovakia, Spain, USA, Uzbekistan.

#### Scientific Programme

Comprehensive investigations of superhigh-energy (7–14 TeV) proton scattering at the Large Hadron Collider with the ATLAS facility will yield utterly new and unique experimental data. Their analysis will allow solution to the most profound physical problems fundamentally important for world outlook.

JINR researchers will take part in solution of some of these problems within the project. Among the most important of them are the clarification of the origin of the elementary particle mass (Higgs mechanism) and search for and investigation of supersymmetry, which will allow an insight into the nature of galactic dark matter and the character of the evolution of our Universe. Other important problems are determination of the applicability boundaries of the modern standard model of elementary particles and observation of evidence for new physical phenomena, such as additional space dimensions or previously unknown particles and interactions. In addition, JINR researchers will get new results allowing more specific knowledge as to the properties of the already known elementary particles such as the W and Z bosons, the top quark, and others.

Implementation of this project aimed at solving highly important scientific problems will result in getting unique applied data.

The “by-products” worth noting are development, debugging, and experience in operation of systems for remote monitoring of highly complicated devices and development and practical use of the distributed computation system (grid) in a long-term, full-scale experiment.

#### Expected main results in 2017:

- Participation in the LHC and ATLAS detector maintenance and upgrades.
- Data development and analysis of the ATLAS data. The new physical results to be obtained in investigations of some key processes of the Standard Model, exotic physics, search for SUSY and heavy quarks physics.
- Development of the ATLAS physics programme: simulation of physical processes, participation in the ATLAS working group, etc.
- Work on the modernization project of the ATLAS detector, including the toroidal magnets, hadron calorimeters and muon spectrometer.
- Detector maintenance and operation.

#### List of projects:

Project	Leader	Priority (period of realization)
1. ATLAS. Physics.	E.V. Khramov	1 (2010 – 2019)
2. Upgrade of the ATLAS Detector	A.P. Cheplakov	1 (2013 – 2018)
3. SANC	A.A. Sapronov	1 (2003 – 2018)

## List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Experiment ATLAS	V.A. Bednyakov E.V. Khramov A.P. Cheplakov	Technical proposal
DLNP V.A. Bednyakov, J.A. Budagov, N.A. Rusakovich, G.A. Chelkov	A.L. Gongadze, I.R. Boyko, M.A. Demichev, Yu.A. Koulchitski, I.A. Minashvili, M.I. Gostkin, D.V. Dedovich, Yu.A. Nefedov, D.V. Kharchenko, Yu.A. Usov, S.N. Malyukov, V.V. Lyubushkin, R.R. Sadykov, M.V. Chizhov, V.V. Glagolev, P.V. Tereshka, Z.U. Usubov, Yu.P. Ivanov, S.N. Karpov, Z.M. Karpova, M.V. Lyablin, G.I. Lykasov, A.A. Sapronov, A.N. Shalyugin, M.M. Shiyakova, V.B. Vinogradov, A.C. Zhemchugov, Yu.L. Vertogradova, A.V. Ershova, N. Huseinov, L.K. Gladilin, I.V. Eletsikh, E.M. Plotnikova, Yu.I. Davydov, S.A. Kotov, V.G. Kruchonok, I.N. Potrap, E. Tschadadze, Yu.Yu. Stepanenko, S.M. Turchikhin	
VBLHEP A.P. Cheplakov	N. Dzhavadov, E.A. Ladygin, F.N. Ahmadov, A.V. Ivanov, V.V. Kukhtin, B.G. Shaykhatdenov, N.G. Fadeev, L.A. Merkulov, V.V. Myalkovsky, A.A. Soloshenko, N.I. Zimin, Yu.A. Filippov	
LIT V.V. Korenkov, P.V. Zrelov	I.N. Aleksandrov, N.I. Gromova, A.V. Yakovlev, V.N. Shigaev, M.A. Mineev, D.A. Oleynik, A.S. Petrosyan	
BLTP D.I. Kazakov	A.V. Gladyshev, A.V. Bednyakov, N.I. Kochelev, A.F. Pikelner, O.B. Teryaev	
FLNP S.A. Kulikov	M.V. Bulavin, E.N. Kulagin, E.P. Shabalin	
2. SANC Project	A.A. Sapronov	Realization
DLNP	L.V. Kalinovskaya, D.Yu. Bardin, R.R. Sadykov, E.D. Uglov, V.A. Kolesnikov, L.A. Rummyantsev	
BLTP	A.B. Arbuzov, S.G. Bondarenko	

## Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	IP NASB
		INP BSU
		JIPNR-Sosny
		NASB
	Gomel	IAP NASB
		GSTU

Canada	Vancouver	GSU
	Montreal	TRIUMF
CERN	Geneva	UdeM
Czech Republic	Prague	CERN
France	Clermont-Ferrand	CU
	Orsay	LPC
Germany	Munich	LAL
	Zeuthen	MPI-P
Georgia	Tbilisi	DESY
Greece	Athens	HEPI-TSU
Israel	Rehovot	UoA
Italy	Pisa	WIS
Netherlands	Amsterdam	INFN
Russia	Moscow	NIKHEF
		LPI RAS
		ITEP
		MSU
	Protvino	IHEP
Slovakia	Bratislava	CU
		IP SAS
Spain	Barcelona	IFAE
USA	Lemont, IL	ANL
Uzbekistan	Samarkand	SSU



## Search for New Physics in Experiments with the Fermilab High-Intensity Muon Beams

**Leader:** V.V. Glagolev  
**Scientific leader:** J.A. Budagov

### Participating Countries and International Organizations:

Belarus, Bulgaria, Georgia, Italy, Russia, Slovakia, USA, Ukraine.

### Scientific Programme

The muon anomalous magnetic moment  $a_\mu$  can be measured and computed to high precision. The comparison between experiment and the SM therefore provides a sensitive search for New Physics (NP). At present, both measurement and theory have sub-part-per-million (ppm) uncertainties, and the “g-2 test” is being used to constrain SM extensions. The difference between experiment and theory,  $\Delta a_\mu(\text{Expt} - \text{SM}) = (255 \pm 80) \times 10^{-11}$  ( $3, 2\sigma$ ), is a highly cited result and a possible harbinger of new TeV-scale physics. Potential explanations of the deviation include: supersymmetry, lepton substructure, dark matter loop etc., all well motivated by theory and consistent with other experimental constraints. Fermilab experiment has a plan to reduce the experimental uncertainty by a factor of 4 or more. A precise g-2 test, no matter where the final value lands, will sharply discriminate among models and will enter as one of the central observables in a global analysis of any SM extensions.

The Mu2e experiment at Fermilab is a dedicated search for the CLFV process  $\mu^- N \rightarrow e^- N$ , which is the coherent conversion of a muon into an electron in the vicinity of a nucleus. Once neutrinos masses are included, the process is allowed but effectively still absent since the rate is proportional to  $(\Delta m_{ij}^2/M_W^2)^2$ , where  $\Delta m_{ij}^2$  is the mass difference squared between i-th and j-th neutrino mass eigenstates, and  $M_W$  is the mass of the W-boson. The predicted rates for the  $\mu^- N \rightarrow e^- N$  and  $\mu^+ \rightarrow e^+ \gamma$  CLFV processes are less than  $10^{-50}$  each. This makes this process a very theoretically clean place to search for NP effects. In many NP models that include a description of neutrino mass, the rates for these processes are enormously enhanced so that they occur at a level to which Mu2e experiment will have sensitivity.

#### Expected main results in 2017:

- Simulation for e.m. calorimeter of the Mu2e experiment.
- Tests of the CsI e.m. calorimeter elements on the gamma sources and electron beam.
- Creation and test of the CRV (cosmic ray veto) modules and counters on proton beam and cosmic muons.
- Development of the final software.
- Participation in development, teating and commissioning of the full DAQ system based on the MIDAS/ROME/PARAVIEW software frameworks for the Muon G-2 experiment.
- Participation in the radiation hardness tests of the detector elements.

### List of projects:

Project	Leader	Priority (period of realization)
1. Search for new physics in experiments with the Fermilab high-intensity muon beams	V.V. Glagolev	1 (2015 – 2017)

## List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Experiment Mu2e	V.V. Glagolev	R&D Realization
DLNP	A.M. Artikov, N.V. Atanov, O.S. Atanova, N.S. Azaryan, V.Yu. Baranov, V.Yu. Batusov, J.A. Budagov, D.Sh. Chokheli, Yu.I. Davydov, D.L. Demin, V.B. Flyagin, A.V. Guskov, Yu.N. Kharzheev, V.I. Kolomoets, S.M. Kolomoets, M.V. Lyablin, Yu.A. Koulchitski, V.M. Romanov, A.V. Sazonova, A.N. Shalyugin, A.V. Simonenko, S.N. Studenov, I.A. Suslov, A.K. Suhanova, I.V. Titkova, V.V. Tereschenko, S.V. Tereschenko, Z.U. Usubov	
BLTP	D.I. Kazakov, G.A. Kozlov, O.V. Tarasov	
LIT	V.V. Korenkov, V.V. Uzhinsky	
VBLHEP	A. Galoyan	
Experiment Muon g-2	N.V. Khomutov	R&D Realization
DLNP	V.A. Baranov, V.N. Duginov, N.P. Kravchuk, N.A. Kuchinsky, T.N. Mamedov, A.I. Rudenko, V.P. Volnykh	
VBLHE	S.A. Movchan	
LRB	V.A. Krylov	

## Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	INP BSU
Bulgaria	Sofia	SU
Georgia	Tbilisi	HEPI-TSU
Italy	Pisa	UniPi
	Frascati	INFN LNF
Russia	Moscow, Troitsk	INR RAS
	Gatchina	PNPI
Slovakia	Bratislava	IP SAS
		CU
USA	Batavia, IL	Fermilab
	Charlottesville, VA	UVa
	Lexington, KY	UK
Ukraine	Kharkov	ISMA NASU

## Study of Neutrino Oscillations

### Leaders:

D.V. Naumov  
A.G. Olshevskiy

### Participating Countries and International Organizations:

China, Czech Republic, France, Germany, Japan, Italy, Slovakia, Turkey, USA.

### Scientific Programme

- Measurement of the  $\theta_{13}$  neutrino mixing angle and  $\Delta m_{ee}^2$  squared mass difference in Daya Bay experiment.
- Measurement of the solar neutrino fluxes in Borexino experiment, search for the sterile neutrino state.
- Study of the neutrino oscillations in OPERA experiment.
- Neutrino mass hierarchy determination and measurement of CP violation phase of the neutrino mixing matrix in JUNO and NOvA experiments.
- R&D for the new photo-detectors and detector equipment for the neutrino experiments.
- Improving of the precision of direct solar neutrino flux measurements with the Borexino detector, phase-II experiment.

### Expected main results in 2017:

- Physics analysis of the Daya Bay experiment data.
- Sensitivity optimization to the mass hierarchy measurements and determination of neutrino oscillation parameters.
- Application of software algorithms for event reconstruction in NOvA experiments.
- Study of NOvA experiment systematic uncertainties related to the neutrino-nucleon cross sections and MSW effects for current NOvA analysis.
- Use of NOvA experiment Remote Operation Centre at JINR for shifts.
- Test of High Voltage prototype for JUNO PMT.
- Measurement of JUNO PMT characteristics.
- OPERA emulsions analysis at JINR.
- Preparation of the OPERA TT detectors for the use in JUNO experiment.
- Measurement of JUNO veto system prototype at JINR using OPERA detectors.
- Event coordinates reconstruction in Borexino detector.
- Analysis of solar neutrino parameters in Borexino detector.

### List of projects:

Project	Leader	Priority (period of realization)
1. BOREXINO	O.Yu. Smirnov	1 (1996 – 2018)
2. Daya Bay/JUNO	D.V. Naumov	1 (2009 – 2017)
3. NOvA	A.G. Olshevskiy	1 (2015 – 2017)

**List of activities:**

<b>Activity or experiment</b> <b>Laboratory or other</b> <b>Division of JINR</b> <b>Responsible person</b>	<b>Leaders</b> <b>Main researchers</b>	<b>Status</b>
1. <b>Experiment BOREXINO</b>  DLNP	<b>O.Yu. Smirnov</b>  K.A. Fomenko, D.V. Korablev, A.P. Sotnikov	Data taking
2. <b>Daya Bay/JUNO Project</b>  DLNP	<b>D.V. Naumov</b> <b>M.O. Gonchar</b>  I.V. Butorov, M.A. Dolgareva, E.A. Naumova, I.B. Nemchenok, A.G. Olshevskiy, A.V. Chukanov, D.V. Taichenachev, N.V. Anfimov, S.V. Biktemerova, Yu.A. Gornushkin, S.G. Dmitrievsky, A.V. Krasnoperov, Z.V. Krumshtein, N.A. Morozov, A.V. Rybnikov, A.B. Sadovsky, A.S. Selunin, O.Yu. Smirnov, K.A. Fomenko, D.V. Fedoseev, M.V. Zhabitsky	Data taking R&D
3. <b>NOvA Project</b>  DLNP	<b>A.G. Olshevskiy</b> <b>O.B. Samoylov</b>  N.V. Anfimov, A.E. Bolshakova, S.G. Dmitrievsky, A.G. Dolbilov, Yu.A. Gornushkin, Ch. Kullenberg, L.D. Kolupaeva, D.V. Naumov, O.N. Petrova, A.B. Sadovsky, A.S. Sheshukov, A.P. Sotnikov	Data taking
BLTP	S.M. Bilenky, K.S. Kuzmin, V.A. Matveev, V.A. Naumov	
LIT	V.V. Korenkov, N.A. Balashov, A.V. Baranov	
4. <b>Experiment OPERA</b>  DLNP	<b>Yu.A. Gornushkin</b>  S.G. Dmitrievsky, Z.V. Krumshtein, A.G. Olshevskiy, S.G. Zemskova, A.V. Chukanov, A.B. Sadovsky, A.S. Sheshukov, A.A. Nozdrin	Data analysis
VBLHEP	Yu.P. Petukhov	
LIT	G.A. Ososkov	
5. <b>Development of new photodetectors and the equipment for application in registering systems of neutrino experiments</b>  DLNP Z.V. Krumshtein	<b>N.V. Anfimov</b>  A.I. Antoshkin, A.G. Olshevskiy, T.V. Rezinko, A.V. Rybnikov, A.V. Selunin, V.V. Chalyshev, I.E. Chirikov-Zorin, D.V. Fedoseev	R&D
VBLHEP Z.Ya. Sadygov	T.Yu. Bokova, I.A. Tyapkin, B.R. Marinova	

**Collaboration**

<b>Country or International Organization</b>	<b>City</b>	<b>Institute or Laboratory</b>
Germany	Hamburg	Univ.

Czech Republic	Aachen	RWTH
France	Prague	CU
Italy	Strasbourg	CRN
China	Salerno	INFN
Slovakia	Beijing	IHEP CAS
USA	Bratislava	CU
	Indianapolis, IN	IUPUI
	Batavia, IL	Fermilab
	Cambridge, MA	Harvard Univ.
Turkey	Ankara	METU
Japan	Tokyo	Toho Univ.

## Experiment PANDA at FAIR

**Leader:** G.D. Alexeev

**Deputies:** A.N. Skachkova  
A.S. Vodopyanov

### Participating Countries and International Organizations:

Belarus, CERN, Czech Republic, Germany, Italy, Russia, Slovakia.

### Scientific Programme

The study of the exotic nuclear-matter states and nucleon structure in the PANDA experiment at FAIR.

#### Expected main results in 2017:

- Inclusion of MC generators into the PANDA software and optimization of the event analysis.
- Calculations of the superconducting solenoid sub-systems.
- Preparation of the FAIR-JINR contract for the production of the PANDA muon system.
- Test of Range System Prototype at CERN PS.

### List of projects:

Project	Leader	Priority (period of realization)
1. PANDA	G.D. Alexeev	1 (2011 – 2019)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. PANDA Project	G.D. Alexeev	Technical proposal
DLNP A.N. Skachkova	V.M. Abazov, N. Angelov, G.A. Golovanov, S.A. Kutuzov, V.L. Malyshev, A.A. Piskun, D.B. Pontekorvo, A.G. Samartsev, N.B. Skachkov, V.V. Tokmenin, A.Yu. Verkheev, L.S. Vertogradov, Yu.L. Vertogradova, N.I. Zhuravlev	
VBLHEP A.S. Vodopyanov	E.A. Strokovsky, M.G. Sapozhnikov, V.K. Dodokhov, M.Yu. Barabanov, V.A. Arefev, V.I. Astakhov, A.A. Efremov, V.I. Lobanov, Yu.Yu. Lobanov, P.V. Nomokonov, I.A. Olex, A.A. Feshchenko, A.S. Galoyan	
LIT	Gh. Adam, V.V. Uzhinsky	
BLTP	A.S. Sorin, O.V. Teryaev, A.V. Efremov	

## **Collaboration**

### **Country or International Organization**

### **City**

### **Institute or Laboratory**

Belarus	Minsk	INP BSU
CERN	Geneva	CERN
Czech Republic	Prague	CU
Germany	Darmstadt	GSI
Italy	Turin	UniTo INFN
Russia	Protvino	IHEP
	Dubna	BSINP MSU
	Omsk	OB IM SB RAS
	St. Petersburg	Neva-Magnet
Slovakia	Bratislava	IP SAS

## Astrophysical Studies in the Experiment TAIGA

**Leader:** L.G. Tkatchev  
**Deputy:** V.M. Grebenyuk

### Participating Countries and International Organizations:

Czech Republic, Germany, Japan, Italy, Mexico, Republic of Korea, Romania, Russia, Ukraine.

### Scientific Programme

- The main topic of multi-messenger TAIGA array are Gamma-ray astronomy, charged cosmic ray physics and particle physics. Gamma-ray astronomy - one of the most intriguing questions in high-energy astroparticle physics is a search for galactic objects for accelerating of particles up to PeV-energies (the so-called Pevatrons); VHE spectra of known sources: where do they stop; absorption in IR and CMB; diffuse emission from galactic plane and local supercluster. Charged cosmic ray physics – the energy spectrum and mass composition measurements from  $10^{14}$  to  $10^{18}$  eV. Particle physics - axion/photon conversion; hidden photon/photon oscillations; Lorentz invariance violation; pp cross-section measurement; search for quark-gluon plasma phenomena.
- The TUS space experiment has been proposed to measure the energy spectrum, composition and angular distribution of the Ultra High Energy Cosmic Rays (UHECR) at  $E \approx 10^{19} - 10^{20}$  eV, to study the region beyond the GZK cutoff. Existence of these particles is beyond the Standard Model of particle physics and is of great interest. The study from the orbit is much more effective in comparison with the ground-based detectors. The existing world statistics is assumed to be increased by a factor of 2 during 3 years of the global data taking. The TUS detector will make it possible to study UHECP neutrino Extensive Air Showers (EAS) from the space orbit.
- The aim of the NUCLEON Project is direct CR measurements in the energy range  $10^{11}$ - $10^{15}$  eV and the atomic charge range up to  $Z \approx 30$  in the near-Earth space to solve mainly the “knee” problem in the CR spectrum. The CR phenomena in this energy region are investigated in terrestrial experiments by measurement of EAS parameters or in balloon or space experiments. Below  $\sim 10^{14}$  eV the spectrum and composition are known from direct observation with detectors placed in balloons and earth satellites. However, at higher energies the CR flux is smaller and more difficult for direct and needs observation. Precise measurement of the CR composition and anisotropy will help to test the existing theoretical concepts and will become a basis for further studies.

### Expected main results in 2017:

- Design and production of IACT for TAIGA experiment.
- Participation in the MC simulation of TAIGA experiment.
- Production and test of the calibration system for TUS detector on the Earth orbit.
- Participation in the data taking of the TUS experiment.
- Participation in the TUS data off-line analysis.
- Participation in the data taking of the NUCLEON experiment and data analysis.



**List of projects:**

<b>Project</b>	<b>Leader</b>	<b>Priority (period of realization)</b>
TAIGA	L.G. Tkatchev	1 (2015 – 2017)

**List of activities:**

<b>Activity or experiment Laboratory or other Division of JINR Responsible person</b>	<b>Leaders Main researchers</b>	<b>Status</b>
<b>1. Experiment TAIGA</b>	<b>L.G. Tkatchev</b>	Realization
DLNP	V.M. Grebenyuk, A.N. Borodin, S.Yu. Porokhovoy, A.V. Tkachenko, F.F. Grinyuk, M. Slunečhka, V. Slunečhkova, N.I. Kalinin, V.F. Boreyko, V.S. Timirbulatov, V.M. Romanov, M. Finger, B.M. Sabirov, Y.I. Sagan, Nguen Man Shat, M.V. Lavrova	
VBLHEP	N.V. Gorbunov	
LIT	S.K. Slepnev	
<b>2. Experiment TUS</b>	<b>L.G. Tkatchev</b>	Realization
DLNP	V.M. Grebenyuk, S.Yu. Porokhovoy, A.V. Tkachenko, F.F. Grinyuk, M. Slunečhka, V. Slunečhkova, M.V. Lavrova, N.I. Kalinin, V.F. Boreyko, V.S. Timirbulatov	
VBLHEP	N.V. Gorbunov	
<b>3. Experiment NUCLEON</b>	<b>L.G. Tkatchev</b>	Realization
DLNP	V.M. Grebenyuk, E.M. Gazeeva, S.Yu. Porokhovoy, N.I. Kalinin, V.F. Boreyko, Nguen Man Shat, B.M. Sabirov, A.B. Sadovsky, A.V. Tkachenko, M.V. Lavrova	
VBLHEP	N.V. Gorbunov	
LIT	V.N. Shigaev, S.K. Slepnev	
FLNP	A.D. Rogov	

**Collaboration**

<b>Country or International Organization</b>	<b>City</b>	<b>Institute or Laboratory</b>
Czech Republic	Prague	CU
Germany	Zeuthen	DESY
	Munich	MPI-P
	Hamburg	Univ.
	Tübingen	Univ.
Japan	Wako	RIKEN

Mexico	Puebla	BUAP
Italy	Turin	UniTo
Poland	Warsaw	UW
Republic of Korea	Seoul	EWU
Romania	Bucharest	ISS
Russia	Moscow	SINP MSU
		NNRU "MEPhI"
	Irkutsk	ISU
	Nauchny	CrAO RAS
	St. Petersburg	KB "Arsenal"
	Moscow, Troitsk	INR RAS
Ukraine	Kiev	BITP NASU

## Investigations of Compressed Baryonic Matter at the GSI Accelerator Complex

**Leaders:** V.P. Ladygin  
V.V. Ivanov  
**Deputy:** P.K. Kurilkin

### Participating Countries and International Organizations:

Bulgaria, Czech Republic, Germany, Mongolia, Romania, Russia, Slovakia, Uzbekistan, Ukraine.

### Scientific Programme

Design of the superconducting dipole magnet, design and development of straw detectors for the CBM experiment at the GSI accelerator complex. Study of the multiparticle dynamics in heavy ion collisions at SIS100 and SIS300. Development of algorithms and software for the trigger, simulation and data analysis. Participation in HADES experimental at SIS18 and SIS100.

#### Expected main results in 2017:

- Preparation of the drawings of individual parts of the superconducting dipole magnet for the CBM experiment.
- Design and testing of the straw detectors.
- Development of the algorithms and software for the trigger and data analysis.
- Simulation of the multiparticle dynamics in heavy ion collisions.
- Development of the mathematical methods and fast computing algorithms for the data analysis and selection of the signal events.
- Participation in experimental data taking using pion, proton and heavy ion beams with HADES at SIS18. Development of the algorithms for data analysis. Further participation in experimental data analysis of  $dp$  (1.25 GeV/nucleon) and  $pp$  (3.5 GeV). Theoretical interpretation of the obtained data.

### List of projects:

Project	Leader	Priority (period of realization)
1. CBM	V.P. Ladygin V.V. Ivanov	1 (2011 – 2020)
2. HADES	V.P. Ladygin	1 (2010 – 2018)

## List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. CBM Project Design and manufacture of the superconducting dipole magnet, and straw detectors. Develop- ment of the algorithms and software for trigger, simulation and data analysis	V.P. Ladygin V.V. Ivanov	Realization
VBLHEP	Yu.S. Anisimov, S.N. Kuznetsov, A.I. Malakhov, O.V. Fateev, V.N. Zryuev, A.P. Ierusalimov, A.P. Zinchenko, D.V. Peshekhonov, P.A. Rukoyatkin, G.D. Kekelidze, I.V. Boguslavsky, V.M. Golovatyuk, V.M. Lysan, O.V. Rogachevsky, A.V. Bychkov	
LIT	V.V. Ivanov, P.V. Zrelov, P.G. Akishin, E.P. Akishina, E.I. Alexandrov, I.N. Alexandrov, D.V. Belyakov, O.Yu. Derenovskaya, V.V. Ivanov (jr), P.I. Kisel, G.E. Kozlov, A.V. Kryanev, S.A. Lebedev, G.A. Ososkov, A.M. Raportirenko, T.P. Sapozhnikova, I.A. Filozova	
DLNP	V.V. Kirakosyan, Yu.L. Vertogradova, S.P. Avdeev, W. Karch	
BLTP	E.-M. Ilgenfritz, D. Blaschke, V.V. Burov, S.G. Bondarenko, V.D. Toneev	
2. Experiment HADES	V.P. Ladygin	Data taking Data analysis
VBLHEP	A.V. Belyaev, O.V. Fateev, A.P. Ierusalimov, P.K. Kurilkin, A.I. Malakhov, A.Yu. Troyan, A.I. Zinchenko	
LIT	V.V. Ivanov, S.A. Lebedev	
DLNP	G.I. Lykasov	

## Collaboration

Country or International Organization	City	Institute or Laboratory
Bulgaria	Sofia	INRNE BAS
Czech Republic	Řež	NPI ASCR
Germany	Darmstadt	GSI
	Dresden	HZDR
	Frankfurt/Main	Univ.
	Giessen	JLU
	Heidelberg	Univ.
Mongolia	Ulaanbaatar	IPT MAS
Romania	Bucharest	IFIN-HH
Russia	Moscow	ITEP

		SINP MSU
		NNRU “MEPhF”
	Moscow, Troitsk	INR RAS
	Protvino	IHEP
Slovakia	Bratislava	IP SAS
		CU
Ukraine	Kiev	BITP NASU
Uzbekistan	Jizakh	JSPI
	Samarkand	SSU

## Study of Rare Charged Kaon Decays in Experiments at the CERN SPS

**Leaders:**

V.D. Kekelidze  
Yu.K. Potrebenikov

**Participating Countries and International Organizations:**

Belgium, Bulgaria, CERN, Czech Republic, Germany, Italy, Mexico, Romania, Russia, Slovakia, United Kingdom, USA.

**Scientific Programme**

Realization of the NA62 Project allows to clarify CP-violation problem, to measure precisely very rare charged kaon decay to charged pions and two neutrinos, to carry out a search for supersymmetric particles and their partners with a goal to observe a physics beyond the Standard Model. In addition, characteristics of rare kaon and hyperon decays will be improved. A high resolution straw-detectors of the NA62 magnetic spectrometer working in vacuum will be supported during experimental runs. Software for simulation, data processing and analysis will be developed.

**Expected main results in 2017:**

- Data taking by the NA62 set-up and data analysis will be carried out.
- Software for the simulation of magnetic spectrometer and full set-up will be developed; system for detector calibration and event reconstruction will be upgraded; common software of the experiment will be developed.
- Calibration, testing and support of the NA62 straw detectors will be carried out.

**List of projects:**

Project	Leader	Priority (period of realization)
1. NA62	V.D. Kekelidze Yu.K. Potrebenikov	1 (2010 – 2018)
2. NA64	V.A. Matveev	1 (2017 – 2019)

**List of activities:**

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Experiment NA62	V.D. Kekelidze Yu.K. Potrebenikov	Data taking Data analysis

VBLHEP

D.T. Madigozhin, S. Gevorgyan, A.I. Zinchenko,  
N.A. Molokanova, L.N. Glonti, I.A. Polenkevich,  
S.N. Shkarovsky, M.H. Misheva, E.A. Gudzovsky,  
V.P. Falaleev, A.A. Belkova, V.N. Gorbunova, L.A. Slepets,  
S.A. Movchan, E.M. Kislov, V.V. Elsha, T.L. Enik,  
A.O. Kolesnikov

## Collaboration

Country or International Organization	City	Institute or Laboratory	
Belgium	Louvain-la-Neuve	UCL	
Bulgaria	Sofia	SU	
	Blagoevgrad	SWU	
	Plovdiv	PU	
	Geneva	CERN	
CERN	Geneva	CERN	
Czech Republic	Prague	CU	
Germany	Mainz	JGU	
Italy	Florence	INFN	
	Ferrara	INFN	
	Frascati	INFN LNF	
	Naples	INFN	
	Perugia	INFN	
	Padua	INFN	
	Pisa	INFN	
	Rome	INFN	
			Univ. "Tor Vergata"
		Turin	INFN
	Mexico	San Luis Potosi	UASLP
Romania	Bucharest	IFIN-HH	
Russia	Moscow, Troitsk	INR RAS	
	Protvino	IHEP	
Slovakia	Bratislava	CU	
United Kingdom	Birmingham	Univ.	
	Bristol	Univ.	
	Glasgow	US	
	Liverpool	Univ.	
USA	Boston, MA	BU	
	Chicago, IL	UChicago	
	Fairfax, VA	GMU	
	Menlo Park, CA	SLAC	
	Merced, CA	UCMerced	
	Upton, NY	BNL	

## CMS. Compact Muon Solenoid at the LHC

**Leader:** A.V. Zarubin  
**Scientific leader:** I.A. Golutvin

### Participating Countries and International Organizations:

Armenia, Austria, Belarus, Belgium, Brazil, Bulgaria, CERN, China, Croatia, Cyprus, Czech Republic, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, India, Iran, Italy, Mexico, New Zealand, Pakistan, Poland, Republic of Korea, Russia, Serbia, Slovakia, Spain, Switzerland, Taiwan, Turkey, Ukraine, United Kingdom, USA, Uzbekistan.

### Scientific Programme

The CMS Collaboration has constructed a general-purpose detector to be operational at the start-up of the Large Hadron Collider (LHC/CERN) to exploit its full discovery potential. Study of fundamental properties of the matter in Super High Energy proton-proton and nucleus-nucleus interactions.

The major activities of JINR are focused on the following directions:

- forward calorimetry, including endcap hadron, and preshower detector;
- forward muon stations with cathode strip chambers;
- development of Physics program to test SM and BSM.

#### Expected main results in 2017:

- Upgrade and technical support of the CMS detectors.
- CMS start up shifts, data taking, and data quality monitoring.
- Processing and analysis of experimental data, development and improvement of muon and jet reconstruction algorithms.
- Development of software for GRID-based distributed system for data processing and analysis. Data transmission from CERN to JINR.

### List of projects:

Project	Leader	Priority (period of realization)
1. CMS	A.V. Zarubin I.A. Golutvin	1 (2010 – 2019)
2. Upgrade of the CMS Detector	A.V. Zarubin I.A. Golutvin	1 (2013 – 2018)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Forward calorimetry	A.V. Zarubin	Upgrade Commissioning Maintenance Data taking



VBLHEP	V.Yu. Alexakhin, S.V. Afanasiev, P.D. Bunin, M.G. Gavrilenko, I.A. Golutvin, N.S. Golova, I.N. Gorbunov, Yu.V. Ershov, N.I. Zamyatin, V.D. Kalagin, A.Yu. Kamenev, L.G. Kobylets, A.M. Kurenkov, V.A. Smirnov, A.I. Malakhov, B.S. Yuldashev	
DLNP	A. Mestvirishvili, M. Finger, M. Finger (Jn.), M. Slunečka, V. Slunečková, Z. Tsamalaidze	
LIT	A. Khvedelidze	
<b>2. Forward muon station ME1/1</b>	<b>V.Yu. Karjavin</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Commissioning Maintenance Data taking</td></tr></table>	Commissioning Maintenance Data taking
Commissioning Maintenance Data taking		
VBLHEP	S.E. Vasiliev, A.O. Golunov, I.A. Golutvin, N.V. Gorbunov, Yu.V. Ershov, N.N. Evdokimov, A.V. Zarubin, A.Yu. Kamenev, A.M. Kurenkov, A.M. Makan'kin, V.V. Perelygin	
LIT	V.V. Palchik, N.N. Voytishin	
<b>3. Upgrade of the CMS detectors</b>	<b>I.A. Golutvin</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Realization</td></tr></table>	Realization
Realization		
VBLHEP	V.Yu. Alexakhin, S.V. Afanasiev, P.D. Bunin, N.V. Gorbunov, V.Yu. Karjavin, A.M. Kurenkov, Yu.V. Ershov, S.E. Vasiliev, A.V. Zarubin, A.M. Makan'kin, A.I. Malakhov, V.V. Perelygin, V.A. Smirnov, B.S. Yuldashev	
LIT	V.V. Palchik, N.N. Voytishin	
<b>4. Reserch physics programme with the CMS detector</b>	<b>S.V. Shmatov</b> <b>I.A. Golutvin</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Realization</td></tr></table>	Realization
Realization		
VBLHEP	V.Yu. Alexakhin, S.V. Afanasiev, M.G. Gavrilenko, I.N. Gorbunov, I.I. Belotelov, P.D. Bunin, A.V. Zarubin, A.Yu. Kamenev, L.G. Kobylets, A.V. Lanev, M.V. Savina, A.I. Malakhov, S.G. Shulga, B.S. Yuldashev	
LIT	V.V. Korenkov, D.A. Oleynik, G.A. Ososkov, V.V. Palchik, A.Sh. Petrosyan, N.N. Voytishin	
BLTP	G.A. Kozlov, A.B. Arbuzov, A.V. Kotikov, A.V. Sidorov, A.V. Efremov, S.G. Bondarenko, R.S. Pasechnik, O.V. Teryaev	
DLNP	G.A. Golovanov, M. Finger, M. Finger (Jr.), N.B. Skachkov, A.N. Skachkova, A.Yu. Verkheev	
<b>5. Development of software for distributed computation, data processing and analysis based on GRID–technology</b>	<b>V.V. Korenkov</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Realization</td></tr></table>	Realization
Realization		
LIT	A.O. Golunov, V.V. Mitsyn, V.V. Palchik, R.N. Semenov, I.A. Filozova, N.N. Voytishin	
VBLHEP	I.I. Belotelov, I.N. Gorbunov, N.V. Gorbunov, A.O. Golunov, S.V. Shmatov	

## Collaboration

Country or International Organization	City	Institute or Laboratory	
Armenia	Yerevan	Foundation ANSL	
Austria	Vienna	HEPHY	
Belarus	Minsk	INP BSU	
	Gomel	BelSUT GSU	
Belgium	Louvain-la-Neuve	UCL	
	Antwerp	UA	
	Brussels	ULB VUB	
	Mons	UMONS	
Brazil	Rio de Janeiro, RJ	CBPF UERJ UFRJ	
	Sao Paulo, SP	Unesp	
	Sofia	SU	
Bulgaria		INRNE BAS	
CERN	Geneva	CERN	
China	Hefei	USTC	
	Beijing	IHEP CAS PKU	
Croatia	Split	Univ.	
Cyprus	Nicosia	UCY	
Czech Republic	Prague	CU	
Estonia	Tallinn	NICPB	
Finland	Helsinki	UH HIP	
	Jyväskylä	UJ	
	Oulu	UO	
	Tampere	TUT	
	France	Annecy-le-Vieux	LAPP
		Lyon	IPNL
Saclay		IRFU	
Georgia	Strasbourg	IPHC	
	Tbilisi	HEPI-TSU AIP TSU	
	Berlin	HUB	
Germany	Aachen	RWTH	
	Karlsruhe	KIT	
Greece	Athens	INP NCSR "Demokritos" UoA	
	Ioannina	UI	

Hungary	Budapest	Wigner RCP	
	Debrecen	Atomki	
India	Mumbai	UD	
	Bhubaneswar	BARC	
	Chandigarh	TIFR	
	Tehran	IOP	
Iran	Tehran	IPM	
Italy	Bari	INFN	
	Bologna	INFN	
	Catania	INFN LNS	
	Florence	INFN	
	Genova	INFN	
	Padua	INFN	
	Pavia	INFN	
	Perugia	INFN	
	Pisa	INFN	
	Rome	INFN	
	Turin	INFN	
	Mexico	Mexico	Cinvestav
	New Zealand	Auckland	Univ.
Christchurch		UC	
Pakistan	Islamabad	QAU	
Poland	Warsaw	UW	
	Otwock-Swierk	NCBJ	
Republic of Korea	Kwangju	CNU	
	Naju	DU	
	Namwon	SU	
	Seoul	KU	
		Konkuk Univ.	
		SNUE	
		CBNU	
Russia	Chongju	ITEP	
	Moscow	LPI RAS	
		NNRU "MEPhI"	
		SINP MSU	
		NIKIET	
		INR RAS	
		PNPI	
		MIPT	
		NSU	
		IHEP	
		VNIITF	
		Electron	
		MDB	
		Moscow, Troitsk	
		Gatchina	
	Dolgoprudny		
	Novosibirsk		
	Protvino		
	Snezhinsk		
	St. Petersburg		
	Zhukovsky		

Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	STU
Spain	Madrid	CIEMAT
		UAM
Switzerland	Oviedo	UO
	Santander	IFCA
	Zurich	ETH
		UZH
	Villigen	PSI
Taiwan	Basel	Uni Basel
	Taipei	NTU
	Chung-Li	NCU
Turkey	Adana	CU
	Ankara	METU
Ukraine	Kharkov	KFTI
		ISC NASU
		KhNU
United Kingdom	London	Imperial College
	Didcot	RAL
	Bristol	Univ.
USA	Ames, IA	ISU
	Baltimore, MD	JHU
	Batavia, IL	Fermilab
	Blacksburg, VA	Virginia Tech
	Boston, MA	BU
		NU
	Cambridge, MA	MIT
	Chicago, IL	UIC
	College Park, MD	UMD
	Columbus, OH	OSU
	Davis, CA	UCDavis
	Gainesville, FL	UF
	Evanston, IL	NU
	Houston, TX	Rice Univ.
	Iowa City, IA	UIowa
	Lincoln, NE	UNL
	Livermore, CA	LLNL
	Los Alamos, NM	LANL
	Los Angeles, CA	UCLA
	Lubbock, TX	TTU
	Madison, WI	UW-Madison
	Minneapolis, MN	U of M
	Notre Dame, IN	ND
	Oxford, MS	UM
	Pasadena, CA	Caltech

Uzbekistan

Pittsburgh, PA  
Piscataway, NJ  
Princeton, NJ  
Riverside, CA  
Rochester, NY  
Tallahassee, FL  
Tuscaloosa, AA  
Tashkent

CMU  
Rutgers  
PU  
UCR  
UR  
FSU  
UA  
INP AS RUz

## Studies of the Nucleon and Hadron Structure at CERN

**Leader:** A.P. Nagaytsev  
**Scientific leader:** I.A. Savin

### Participating Countries and International Organizations:

Armenia, Bulgaria, CERN, Czech Republic, France, Germany, Israel, Italy, Japan, Poland, Russia, Switzerland, Ukraine, United Kingdom, USA.

### Scientific Programme

Studies of the generalized parton distributions in various exclusive processes. Studies of the exclusive production of photons, pions and vector mesons in DIS and DVCS. Measurements of nucleon structure in the Drell–Yan processes. Study of inclusive and semi-inclusive processes in Deep Inelastic Scattering (DIS) of muons and hadrons on polarized targets.

- Measurements of the nucleon structure functions, polarized parton distributions.
- Measurements of nucleons structure in the Drell–Yan processes.
- Studies of the inclusive production of photons, pions and  $\rho$ -mesons in DIS and DVCS.
- Software creation and development for simulation and data analysis. System support of CERN software in COMPASS-II.
- Detector preparation for the COMPASS-II spectrometer.

### Expected main results in 2017:

- Measurement of asymmetries in processes of the exclusive birth of photons (DVCS),  $\pi$ -mesons and vector mesons.
- Participation in the data taking.
- Maintenance of the hadron calorimeter HCAL1 and muon system MW1.
- Preparation for a data taking the new electromagnetic calorimeter ECALO. Support of ECALO during data taking.
- Software development and simulation of the various reactions, studied in COMPASS-II. Analyzing of the COMPASS-II data at JINR and publications preparation.
- Theoretical studies for COMPASS-I and COMPASS-II.

### List of projects:

Project	Leader	Priority (period of realization)
1. COMPASS-II	A.P. Nagaytsev	1 (2011 – 2017)

**List of activities:**

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
I. Experiment COMPASS	A.P. Nagaytsev	Data taking Data analysis
1. Hadron calorimeter	I.A. Savin O.P. Gavrishchuk	Maintenance
VBLHEP	G.V. Meshcheryakov, A.S. Yukaev, V.A. Anosov	
DLNP	A.S. Selyunin	
2. Electromagnetic calorimeter	A.P. Nagaytsev, Z.V. Krumshtein	Preparation R&D
VBLHEP	V.V. Astakhov, O.P. Gavrishchuk, G.V. Meshcheryakov, A.S. Yukaev, N.S. Rogacheva, O.M. Kuznetsov, V.A. Anosov	
DLNP	A.I. Antoshkin, V.M. Kudryavtsev, M.V. Nikitin, I.E. Tchirikov–Zorin, N.V. Anfimov, T.V. Rezinko, I.A. Orlov, V.V. Tchalyshev, A.V. Rybnikov, D.V. Fedossev, A.S. Selyunin, A.G. Olshevskiy, O.V. Gromov	
3. Muon system	G.D. Alekseev	Maintenance
DLNP	V.M. Abazov, L.S. Vertogradov, N.I. Zhuravlev, N.A. Kutchinsky, V.L. Malyshev, A.A. Piskun, A.G. Samartsev, V.V. Tokmenin, G.A. Golovanov	
4. Software development. Data analysis	E.V. Zemlyanichkina	Realization
VBLHEP	I.A. Savin, D.V. Peshekhonov, G.I. Smirnov, N.O. Mitrofanov, A.P. Nagaytsev, O.M. Kuznetsov, Yu.I. Ivanshin, N.S. Rogacheva, R.R. Akhunzyanov, R. Gushcherski, A.V. Ivanov, V.S. Batozskaya, E.A. Salmina	
DLNP	A.G. Olshevskiy, A.V. Guskov, Z.V. Krumshtein, E.O. Mitrofanov, A.F. Gridin, I.A. Orlov, T.V. Rezinko, A.V. Rybnikov, A.S. Selyunin	
LIT	P.V. Zrelov	
5. Measurements of generalized parton distributions and transverse spin structure in Drell–Yan processes	A.P. Nagaytsev I.A. Savin	Realization
VBLHEP	O.P. Gavrishchuk, G.V. Meshcheryakov, O.M. Kuznetsov, Yu.I. Ivanshin, R.R. Akhuzyanov, N.S. Rogacheva, E.V. Zemlyanichkina, A.V. Ivanov	
DLNP	A.G. Olshevskiy, Z.V. Krumshtein, A.V. Guskov, K.Yu. Gasnikova, I.A. Orlov, N.V. Anfimov, T.V. Rezinko, A.V. Rybnikov, A.S. Selyunin	

BLTP

**6. Preparation of the project  
on measurement of proton  
form-factor ratios  
at 13–15 GeV/c**

VBLHEP

**II. Theoretical studies**

BLTP

A.V. Efremov, O.V. Teryaev

**I.A. Savin**  
**N.M. Piskunov**

Project preparation

O.P. Gavrishchuk, G.V. Meshcheryakov

**A.V. Efremov**

Realization

S.B. Gerasimov, O.V. Teryaev, A.V. Kotikov,  
A.E. Dorokhov, N.I. Kochelev, A.M. Sidorov

**Collaboration**

**Country or International  
Organization**

**City**

**Institute or Laboratory**

Armenia	Yerevan	Foundation ANSL
Bulgaria	Sofia	INRNE BAS
		SU
CERN	Geneva	CERN
Czech Republic	Prague	CU
France	Saclay	IRFU
Germany	Bielefeld	Univ.
	Bochum	RUB
	Bonn	UniBonn
	Freiburg	Univ.
	Hamburg	DESY
	Heidelberg	MPIK
	Munich	LMU
		TUM
	Mainz	JGU
	Erlangen	FAU
Israel	Tel Aviv	TAU
Italy	Turin	INFN
	Trieste	INFN
	Frascati	INFN LNF
Japan	Chiba	Toho Univ.
	Nagoya	Nagoya Univ.
	Osaka	OCU
	Sendai	Tohoku Univ.
	Tsukuba	KEK
	Yamagata	Yamagata Univ.
Poland	Warsaw	UW
Russia	Moscow	SINP MSU
		LPI RAS
	Moscow, Troitsk	INR RAS
	Gatchina	PNPI



Switzerland  
Ukraine  
United Kingdom  
USA

Protvino  
Zurich  
Kharkov  
Liverpool  
Urbana, IL

IHEP  
UZH  
ISMA NASU  
Univ.  
I

## Strangeness in Hadronic Matter and Study of Inelastic Reactions Near Kinematical Borders

**Leaders:** E.A. Strokovsky  
E.S. Kokouline

**Participating Countries and International Organizations:**  
Belarus, Czech Republic, Germany, Japan, Russia, Ukraine.

### Scientific Programme

Strangeness in hadronic matter and study of boundary effects:  
study of stabilizing effects of strangeness in nuclear matter and properties of the lightest hypernuclei;  
study of multi-particle dynamics in inelastic proton-proton and proton-nucleus interactions with extremely high multiplicity;  
study of spectra and yields of soft photons in deuteron-nucleus and nucleus-nucleus interactions.

#### Expected results:

- Data on production cross sections for hyper-fragments of relativistic nuclei. Data on the lifetimes and binding energies of the lightest hypernuclei  ${}^4_{\Lambda}H$ ,  ${}^3_{\Lambda}H$ ,  ${}^6_{\Lambda}H$ ; search for  ${}^6_{\Lambda}H$ . Study of the decay channels, including non-mesonic decays of the  ${}^{10}_{\Lambda}Be$  and  ${}^{10}_{\Lambda}B$  hypernuclei.
- New experimental data about the drip-line location for loosely bound light hypernuclei with high neutron excess. Development of theory of the neutron-rich hyper nuclei and models of their production in non-central nucleus-nucleus interactions.
- New experimental data about soft photon emission in deuteron-nuclei and other nuclei-nuclei interactions, including study of dependence of their energy spectra on electric charges of the projectile and target nuclei, as well as on multiplicity of secondaries.
- Development of theoretical and phenomenological models for description of data on the soft photon yield in the deuteron-nuclei and other nuclei-nuclei interactions, differentiated on multiplicity of secondaries.
- Construction of two-arm electromagnetic calorimeter for soft photon registration in a wide region of emission angles for study of interference patterns, for search of new resonances and verification of theoretical predictions about new phenomena in a dense nuclear matter.

#### Expected main results in 2017:

- Modernization of the FFE, DAQ and tracking systems of the NIS-GIBS spectrometer.
- Data taking on the hyper-nuclear program (search for the hyper-hydrogen 6) using the NIS-GIBS spectrometer at extracted beams of deuterons and  ${}^7Li$  nuclei.
- Analysis of data from LEPS spectrometer on vector-meson photoproduction by polarized photons.
- Analysis of data on soft ( $E_{\gamma} < 50$  MeV) photon emission in deuteron-nuclei and other nuclei-nuclei interactions at kinetic energies above 2 GeV/nucleon.
- Preparation of the NEMAN project aimed on study of photon emission in non-central collisions of relativistic (with kinetic energies above 1 GeV/nucleon) light and heavy nuclei with nuclei at the BM@N setup.

**List of projects:**

<b>Project</b>	<b>Leader</b>	<b>Priority (period of realization)</b>
1. HyperNIS	E.A. Strokovsky	1 (2010 – 2018)

**List of activities:**

<b>Activity or experiment Laboratory or other Division of JINR Responsible person</b>	<b>Leaders Main researchers</b>	<b>Status</b>
1. Experiment NIS–GIBS	E.A. Strokovsky J. Lukstins	Realization Data taking
VBLHEP	V.D. Aksinenko, R.A. Salmin, V.P. Balandin, S.N. Bazylev, P.A. Rukoyatkin, A.A. Feschenko, S.N. Plyashkevich, Yu.T. Borzunov, A.I. Maksimchuk, V.B. Chumakov, V.Yu. Ivanenko, O.V. Okhrimenko, A.I. Golokhvastov, S.A. Avramenko, M.H. Anikina, A.V. Averiyarov, A.M. Korotkova, N.G. Parfenova, S.V. Starikova, V.B. Dunin, A.V. Kazakov, A.S. Chichin, A.V. Konstantinov	
DLNP	V.V. Tereschenko	
OCE	A.N. Parfenov	
2. Experiment NEMAN	E.S. Kokoulina V.A. Nikitin	Project preparation Data taking
VBLHEP	V.I. Kireev, V.V. Avdeychikov, Yu.A. Chentsov, I.A. Rufanov, M.V. Tokarev, Yu.P. Petukhov, A.N. Aleev, A.I. Yukaev, N.K. Zhidkov, V.B. Dunin, A.V. Kazakov, I.S. Mironov, A.S. Chichin, V.P. Balandin, N.F. Furmanets, Yu.T. Borzunov, N.A. Kuzmin, P.K. Manyakov, A.V. Konstantinov	
BLTP	Yu.A. Bystritsky	

**Collaboration**

<b>Country or International Organization</b>	<b>City</b>	<b>Institute or Laboratory</b>
Belarus	Minsk	INP BSU
		BSUIR
Czech Republic	Gomel	IAP NASB
		GSTU
		GSU
		CTU
Germany	Prague	UJV
		NPI ASCR
		Univ.
Germany	Frankfurt/Main	

Japan	Jülich	FZJ
Russia	Osaka	RCNP
	Moscow	SINP MSU
		MSU
		NNRU "MEPhI"
	Protvino	IHEP
	Syktyvkar	DM Komi SC UrB
Slovakia	Banska Bistrica	RAS
Ukraine	Kiev	UMB
		BITP NASU

## Development of the JINR Basic Facility for Generation of Intense Heavy Ion and Polarized Nuclear Beams Aimed at Searching for the Mixed Phase of Nuclear Matter and Investigation of Polarization Phenomena at the Collision Energies up to $\sqrt{s_{NN}} = 11$ GeV

**Leaders:** A.S. Sorin  
V.D. Kekelidze  
G.V. Trubnikov

**Deputies:** I.N. Meshkov  
A.D. Kovalenko

### Participating Countries and International Organizations:

Armenia, Azerbaijan, Belarus, Bulgaria, CERN, China, Czech Republic, Egypt, France, Georgia, Germany, Italy, Israel, Japan, Moldova, Poland, Romania, Russia, Slovakia, South Africa, Sweden, Ukraine, USA.

### Scientific Programme

Search and investigation of phase transitions and critical phenomena in strongly interacting matter at extremely high baryon densities, of nucleon spin structure, study of polarization phenomena in few-body systems and light nuclei. Development of theoretical models of these processes and theoretical support of the experiments. Development of the Nuclotron accelerator complex as a basic facility for studying relativistic nuclear collisions in the range of atomic masses  $A = 1-197$  and the construction of the BM@N detector. Studies of the reaction dynamics and the in-medium properties of hadrons, production of strange hyperons at the threshold and search for hyper-nuclei in interactions of heavy ion beams of the Nuclotron with fixed targets. The study at the detector BM@N of nuclear structure at small internucleon distances. Development and construction of the heavy ion collider NICA, multipurpose detector (MPD/NICA) and spin physics detector (SPD/NICA) for the collide experiments with heavy ions. Modernization of the extraction beam lines. Carrying out of experiments with nuclear beams and polarized deuteron beams at the Nuclotron

#### Expected main results in 2017:

- Development and extension of the NICA “White Paper” – project physics program. Continuation of theoretical studies of non-perturbative QCD processes, development and tests of the models for the nuclear matter at high temperatures and densities aimed at investigation of phases of nuclear matter, dynamics of nuclear collisions at extremely high baryonic densities and observation of these phenomena in P-odd effects and spin asymmetries.
- The Nuclotron modernization in framework of the Nuclotron–NICA project: continuation of the operational regimes optimization of the heavy ion source KRION-6T, design and beginning of creation of the operational heavy ion source KRION-N, technical improvement of the cryogenic and injection complex. Development of the system for beam diagnostics. Put into operation the polarized particle source SPI. Annual dedicated machine development runs at Nuclotron on first priority tasks within running time of 400 hours. Start of conceptual design of superconducting resonator for proton linac.
- Completion of the linear heavy ion accelerator HILAC ( $z/A \geq 0.14$ ) commissioning, obtain of the design parameters. Put into operation RFQ fore-injector for LU-20. Acceleration of polarized deuteron beam at the Nuclotron. Continuation of the serial production of superconducting for the NICA project. Development and creation of test benches, modernization of the engineering infrastructure.
- Preparation of the technical project for the beam transfer line from Booster to Nuclotron.

- Preparation of working project for housing of the NICA collider elements and systems, continuation of the civil construction.
- Construction and commissioning of the first stage of the BM@N experimental setup, collection of first experimental data of interactions of light and medium ion beams with fixed targets. Perform simulation of the counting rate for the measurements of correlation of three nucleons. Prepare technical design for measurements of the short range correlation with additional detectors and additional radiation protection.
- Realization of the technical project of the MPD solenoid and the order for its manufacturing. Prototyping the detector elements for the first stage of the project. MPD Technical Design Project preparation.
- Preparation of the Conceptual Design Project to study nucleon spin structure with SPD. Continuation of theoretical studies of the Matveev–Muradyan–Tavkhelidze–Drell–Yan processes, production processes and other processes in light polarized nuclei collisions.
- Nuclotron runs dedicated to physics and machine development within running time of 1000 hours.
- Development of the NICA/MPD/BM@N/SPD computer infrastructure.

### List of projects:

Project	Leader	Priority (period of realization)
1. Nuclotron–NICA	G.V. Trubnikov <b>Scientific leader</b> I.N. Meshkov	1 (2011 – 2020)
2. MPD	V.D. Kekelidze	1 (2011 – 2020)
3. BM@N	M.N. Kapishin	1 (2012 – 2021)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Theoretical investigations, lattice QCD calculations and development of the models for description of properties of excited nuclear matter at high temperatures and compressions, dynamics of nuclear interactions at extremely dense baryon matter, spin and P–odd effects	A.S. Sorin O.V. Teryaev D. Blaschke	Realization
BLTP	A.V. Efremov, A.S. Hovorostukhin, E.–M. Ilgenfritz, S.B. Gerasimov, M.K. Volkov, A. Parvan, Ya.N. Klopot, S.N. Nedelko, A.G. Oganessian, A. Frisen	
LIT	Yu.L. Kalinovsky, Zh. Musulmanbekov, E.G. Nikonov	
DLNP	G.I. Lykasov	
VBLHEP	V.D. Kekelidze, R. Lednický, A.I. Malakhov, A.G. Litvinenko, D.A. Artyemenkov, D.K. Dryablov, Kh.U. Abraamyan, M.A. Kozhin, S.G. Reznikov, V.N. Zhezher, O.V. Rogachevsky, V. Voronyuk, P. Batyuk	

**2. Nuclotron–NICA: development of the technological systems of the accelerator ring, injection complex and extracted beam channels in framework of the NICA project**

VBLHEP

**A.V. Butenko  
V.I. Volkov  
E.M. Syresin**

Realization
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H.G. Khodzhbagiyan, O.M. Golubitsky, E.V. Shevtchenko, N.N. Agapov, V.I. Batin, N.A. Baldin, S.P. Gorelikov, S.V. Gudkov, K.Sh. Kozlovski, V.A. Kosinov, N.E. Emelianov, I.M. Petrov, O.B. Yarovikova, A.B. Arefiev, A.S. Averichev, M.V. Kondratiev, N.L. Egorova, R.V. Peshkov, V.I. Lipchenko, V.E. Kurinov, Yu.A. Mitrofanova, E.V. Gromova, V.V. Orlov, S.A. Sidorov, E.Yu. Filippova, E.Yu. Ivanenko, D.V. Lobanov, A.V. Alfeev, V.A. Monchinsky, A.I. Govorov, M.Yu. Averianov, V.P. Akimov, V.P. Boytsov, E.I. Bufrinov, S.V. Gydkov, N.I. Garandza, V.V. Seleznev, R.G. Pushkar, K.A. Levterov, A.A. Voronin, B.V. Golovensky, K.B. Shevchenko, V.P. Vadeev, D.A. Lyuosev, I.V. Shirikov, A.A. Martynov, A.V. Smirnov, A.S. Romanov, Yu.V. Ryazantsev, P.N. Sotnikov, V.G. Shabratov, A.R. Galimov, A.V. Nesterov, G.L. Kuznetsov, O.A. Kunchenko, R.V. Pivin, A.M. Bazanov, E.E. Donets, E.D. Donets, D.E. Donets, V.B. Shutov, D.O. Ponkin, V.S. Alexandrov, V.A. Andreev, V.A. Isadov, A.V. Eliseev, S.V. Romanov, V.V. Tarasov, A.E. Kirichenko, V.V. Kovalev, A.G. Kochurov, V.A. Mikhaylov, D.V. Monakhov, G.S. Sedykh, B.V. Vasilishin, O.S. Kozlov, O.I. Brovko, A.M. Nikitin, V.M. Shumkov, O.V. Prozorov, A.V. Gromov, A.Yu. Grebentsov, K.N. Gurylyev, G.E. Ivanov, S.A. Rumyantsev, L.P. Skiba, A.N. Pisulina, I.V. Kudashkin, G.P. Reshetnikov, N.N. Blinnikov, L.E. Bogdan, K.N. Gurylev, E.V. Ivanov, M.G. Kochurov, A.M. Malyshev, A.L. Cvetov, Z.I. Smirnova, V.N. Karpinsky, A.L. Osipenko, A.N. Scherbakov, R.V. Andryukhin, I.I. Kalagin, A.V. Kopchenov, N.G. Kondratiev, A.V. Kudashkin, A.A. Shurygin, Yu.M. Nozhenko, T.N. Agafonova, S.V. Kirov, T.A. Kulaeva, N.A. Filippov, A.S. Shakhmatov, V.G. Tovstukha, V.V. Fyedorov, A.S. Vinogradov, N.A. Blinov, A.V. Karavaev, V.V. Shugaev, R.M. Akhmarizyalov, N.A. Zhiltsova, A.Yu. Starikov, P.A. Rukoyatkin, A.V. Tuzikov, A.V. Filippov, I.V. Gorelyshev, V.V. Filimonov, N.I. Lebedev, E.V. Gorbachev, V.V. Fimuskin, L.V. Kutuzova, G.D. Shirkov, V.V. Kobets, A.V. Alfeev, S.I. Nefediev, S.V. Kutenkov, N.V. Semin, V.P. Chernyaev, Yu.A. Svintitsky, A.Yu. Svintitsky, V.Yu. Zhurin, A.I. Korobkov, M.I. Migulin, A.A. Fateev, O.Yu. Fedotov, A.I. Sidorov, S.N. Sedykh, N.D. Topilin, A.V. Bychkov, E.V. Voronina, T.F. Prakhova, G.A. Titova, A.V. Shabunov, V.M. Slepnev, I.V. Slepnev, I.A. Filippov, A.V. Shutov

3. R&D work, construction of the prototypes and full-scale superconducting magnets for NICA booster and collider

VBLHEP

**G.V. Trubnikov**  
**G.G. Khodzhbagiy**  
**S.A. Kostromin**

Realization
-------------

A.V. Butenko, A.V. Smirnov, E.V. Shevtchenko, A.S. Sergeev, A.V. Nesterov, O.M. Golubotsky, A.R. Galimov, G.L. Kuznetsov, O.A. Kunchenko, P.V. Pivin, A.M. Bazanov, N.N. Agapov, V.I. Batin, V.M. Drobin, Yu.T. Borzunov, L.V. Petrova, A.V. Konstsntinov, E.A. Kulikov, A.S. Averichev, V.N. Karpinsky, A.L. Osipenkov, N.P. Bazyleva, A.V. Kudashkin, N.A. Filippov, A.S. Vinogradov, N.A. Blinov, A.M. Donyagin, N.N. Agapov, H. Malinovski, V.I. Lipchenko, V.E. Kurinov, Yu.A. Mitrofanova, S.A. Smirnov, E.Yu. Filippova, E.Yu. Ivanrnko, D.V. Lobanov, A.Yu. Starikov, D.O. Ponkin, A.Yu. Merkuriev, R.A. Karpunin, I.E. Karpunina, S.A. Dolgy, V.K. Alexeev, V.N. Surikov, N.A. Zhiltsova, N.D. Topilin, Yu.V. Gusakov, A.V. Shabunov, A.A. Makarov, Yu.A. Tumanova, T.F. Prakhova, V.V. Agapova, A.V. Buchkov, V.S. Korolev, V.V. Borisov

4. Commissioning of the heavy ion source (KRION-6 T), commissioning the polarized particle source (SPI) for the NICA complex

VBLHEP

**E.D. Donets**  
**E.E. Donets**  
**V.V. Fimushkin**

Realization
-------------

V.B. Shutov, D.N. Rassadov, A.Yu. Ramzdorf, D.E. Donets, A.Yu. Boitsov, D.O. Ponkin, V.P. Vadeev, Yu.V. Prokofichev, L.V. Kutuzova, V.V. Myalkovsky, A.V. Vadeev, A.I. Govorov, V.V. Seleznev, A.V. Shabunov, K.A. Levterov, S.N. Sedykh, I.I. Golubev, A.D. Kovalenko

5. Development and construction of the beam injection/extractin systems, beam transportation channels for NICA elements. Development of the control systems for beam diagnostics

VBLHEP

**V.I. Volkov**  
**V.A. Mikhaylov**

Realization
-------------

A.V. Butenko, B.V. Vasilishin, O.S. Kozlov, A.G. Kochurov, L.A. Leonov, A.V. Eliseev, V.A. Andreev, V.M. Gorchenko, S.V. Mikhaylov, A.M. Butenko, G.M. Salnikova, V.A. Isadov, S.V. Romanov, A.E. Kirichenko, P.A. Rukoyatkin, R.I. Kukushkina, V.S. Alexandrov, A.V. Tuzikov, A.A. Fateev, N.I. Lebedev, V.V. Tarasov, L.I. Kosukhina, G.S. Sedukh, T.V. Rukoyatkina, V.V. Kovalev, N.V. Pilyar, G.E. Koroleva, M.E. Pushkin, E.V. Gorbachev, R.A. Smolkov, A.V. Alfeev, S.I. Nefediev, V.N. Karpinsky, A.L. Osipenkov, A.I. Sidorov, S.N. Sedykh, S.Yu. Kolesnikov, Yu.A. Tumanova

6. Development of the cryogenic systems for Nuclotron-NICA

**N.N. Agapov**  
**H.G. Khodzhbagiy**

Projecting Realization
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VBLHEP

V.I. Batin, H. Malinovski., N.A. Baldin, S.P. Gorelikov, S.V. Gudkov, K.K. Kozlovski, V.A. Kosinov, N.E. Emelianov, I.M. Petrov, O.B. Yarovikova, A.B. Arefiev, M.A. Basheva, D.M. Belov, E.I. Vorobiyev, I.N. Goncharov, E.V. Gromova, M.V. Kondratiev, N.L. Egorova, V.V. Orlov, S.A. Sidorov, O.B. Yarovikova, R.V. Peshkov, E.V. Ivanov, V.M. Drobin, Yu.T. Borzunov, A.V. Konstantinov, L.V. Petrova, E.A. Kulikov, A.S. Averichev, V.I. Lipchenko, V.E. Kurinov, Yu.A. Mitrofanova, S.A. Smirnov, E.Yu. Filippova, E.Yu. Ivanenko, D.V. Lobanov

**7. Technical design, construction and development of the NICA injection complex**

**A.V. Butenko**  
**V.V. Kobets**  
**V.A. Monchinsky**

Realization
-------------

VBLHEP

A.O. Sidorin, A.I. Govorov, V.V. Seleznev, A.A. Martynov, K.V. Shevtchenko, K.A. Levterov, A.A. Voronin, B.V. Golovensky, V.P. Vadeev, D.A. Lyuosev, I.V. Shirikov, A.V. Smirnov, A.V. Nesterov, A.M. Bazanov, L.V. Zinoviev, D.E. Donets, R.V. Pivin, N.D. Topilin, A.I. Sidorov, V.S. Shvetsov, A.A. Fateev, I.G. Lebedeva, S.N. Sedykh, A.P. Kozlov, V.V. Kosukhin, A.V. Tuzikov, N.I. Garandza, V.V. Filimonov, A.S. Romanov, M.Yu. Averianov, V.P. Akimov, S.V. Mikhaylov, E.M. Syresin

**8. Technical design and construction of the NICA booster synchrotron and its technological systems**

**A.V. Butenko**  
**V.A. Mikhaylov**  
**A.O. Sidorin**  
**E.M. Syresin**

Project preparation Realization
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VBLHEP

G.G. Khodzhibagiyan, S.A. Kostromin, A.V. Smirnov, A.V. Nesterov, L.V. Zinoviev, A.S. Sergeev, A.R. Galimov, G.L. Kuznetsov, O.A. Kunchenko, R.V. Pivin, A.M. Bazanov, V.V. Seleznev, N.N. Agapov, V.I. Batin, V.M. Drobin, Yu.T. Borzunov, L.V. Petrova, A.V. Konstantinov, E.A. Kulikov, A.S. Averichev, V.I. Lipchenko, V.E. Kurinov, Yu.A. Mitrofanova, V.N. Karpinsky, A.L. Osipenkov, A.N. Scherbakov, R.V. Andryukhin, I.I. Kalagin, A.V. Kopchenov, N.G. Kondratiev, A.V. Kudashkin, A.A. Shurygin, O.I. Brovko, N.D. Topilin, Yu.V. Gusakov, A.V. Shabunov, Yu.A. Tumanova, V.I. Volkov, B.V. Vasilishin, O.S. Kozlov, V.A. Andreev, A.V. Eliseev, S.V. Romanov, A.E. Kirichenko, P.A. Rukoyatkin, A.V. Tuzikov, A.A. Fateev, N.I. Lebedev, V.V. Tarasov, T.V. Rukoyatkina, E.V. Gorbachev, A.V. Alfeev

DLNP

I.N. Meshkov, S.L. Yakovenko, E.V. Akhmanova, A.G. Kobets, A.Yu. Rudakov, N.A. Rybakov

9. **Technical design, R&D and construction of the heavy ion collider NICA with energy  $\sqrt{s_{NN}} = 4\div 11$  GeV and average luminosity  $1 \cdot 10^{27} \text{cm}^{-2} \cdot \text{s}^{-1}$  and light polarized ions on the base of Nuclotron – M**

VBLHEP

I.N. Meshkov  
G.V. Trubnikov  
A.O. Sidorin  
A.D. Kovalenko

Project preparation Realization
------------------------------------

G.G. Khodzhbagiyani, A.V. Butenko, E.M. Syresin, A.V. Smirnov, S.A. Kostromin, V.F. Get'man, A.V. Nesterov, A.G. Nikandrov, A.R. Galimov, G.L. Kuznetsov, R.V. Pivin, A.M. Bazanov, N.N. Agapov, V.I. Batin, V.M. Drobin, H. Malinovski, Yu.T. Borzunov, L.V. Petrova, A.V. Konstantinov, E.A. Kulikov, A.S. Averichev, N.V. Semin, V.D. Kalagin, N.D. Topilin, Yu.V. Gusakov, A.V. Shabunov, E.V. Muraveva, A.A. Makarov, Yu.A. Tumanova, V.I. Volkov, B.V. Vasilishin, O.S. Kozlov, V.A. Andreev, A.V. Eliseev, S.V. Romanov, A.E. Kirichenko, P.A. Rukoyatkin, A.V. Tuzikov, A.A. Fateev, N.I. Lebedev, V.V. Tarasov, T.V. Rukoyatkina, E.V. Gorbachev, A.V. Alfeev, V.N. Karpinsky, A.N. Scherbakov, R.V. Andryukhin, I.I. Kalagin, A.L. Osipenkov, A.V. Kopchenov, N.G. Kondatiev, A.V. Kudashkin, A.A. Shurygin, V.A. Monchinsky, O.I. Brovko, O.V. Prozorov, A.V. Gromov, A.Yu. Grebentsov, V.M. Zhabitsky, G.D. Shirkov, V.S. Alexandrov, A.V. Filippov, E.I. Urazakov, E.V. Ivanov

DLNP

A.G. Kobets, T.A. Stepanova, L.V. Soboleva, E.V. Akhmanova, A.A. Sidorin, S.L. Yakovenko

LRB

G.N. Timoshenko, V.N. Buchnev, V.Yu. Shchegolev

10. **Design and construction of the MPD detector. Preparation of the Technical Design Project. R&D and construction of the first-stage detector elements: time-projection chamber, time-of-flight system, electromagnetic calorimeter, zero-degree calorimeter, internal tracker. System of luminosity control**

VBLHEP

V.D. Kekelidze  
A.S. Sorin  
V.M. Golovatyuk

R&D Technical proposal
---------------------------

S.V. Volgin, N.M. Vladimirova, V.A. Babkin, M.G. Buryakov, D. Dabrovsky, A.V. Dmitriev, P.O. Dulov, S.N. Lobastov, V.A. Petrov, K. Roslon, M.M. Rumyantsev, Yu.I. Fedotov, H.U. Abraamyan, A.B. Anisimov, M.A. Kozhin, O.P. Gavrishchuk, N.A. Kuzmin, A.I. Yukaev, E.A. Ladygin, S.Ya. Sychkov, Yu.P. Petukhov, E.A. Usenko, D.S. Erin, S.N. Nagorny, V.P. Balandin, E.V. Kostyukhov, Yu. Lukstins, A.I. Malakhov, A.V. Pilyar, O.V. Fateev, A.M. Korotkova, V.F. Chepurnov, S.V. Razin, R.R. Rybakov, V.N. Zryuev,

V.M. Samsonov, A.V. Averyanov, A.G. Bazhazhin, S.V. Vereshchagin, S.A. Zaporozhets, A.G. Litvinenko, A.Yu. Isupov, V.F. Peresedov, I.I. Migulina, V.I. Shokin, L.S. Zolin, V.A. Nikitin, O.V. Rogachevsky, K.V. Gertsenberger, Yu. Fedorishin, A.I. Zinchenko, I.P. Slepov, P.S. Geraksiev, Dzh. Drnoyan, I.A. Tyapkin, I.V. Gapienko, M.A. Ilieva, L.S. Iordanova, A.V. Ivanov, D.A. Suvarieva, B. Marinova, G.D. Kekelidze, V.V. Myalkovsky, Yu.T. Kiryushin, S.A. Movchan, V.M. Lysan, S.V. Khabarov, V.S. Khabarov, A.V. Vishnevsky, Yu.K. Potrebenikov, D.T. Madigozhin, N.A. Molokanova, I.A. Polenkevich, G.N. Agakishiev, S.N. Shkarovsky, V.A. Vasendina, V.A. Nikitin, N.K. Zhidkov, V.I. Yurevich, G.S. Averichev, D.N. Bogoslovsky, V.B. Dunin, L.G. Efimov, E.M. Kislov, S.V. Sergeev, A.A. Timoshenko, A.A. Povtoreiko, V.V. Tikhomirov, G.A. Yarygin, A.N. Zubarev, S.V. Bazylev, V.M. Slepnev, I.V. Slepnev, A.B. Shutov, A.E. Baskakov, A.V. Shchipunov, N.A. Shutova, R.V. Nagdasev, N.A. Tarasov, V.O. Sidorenko, S.N. Kuhlin, I.A. Filippov, A.V. Terletsky, Yu.A. Murin, D.V. Dementiev, A.D. Sheremetiev, A.L. Voronin, V.V. Elsha, T.V. Semchukova, T.V. Andreeva, S.Yu. Udovenko, N.I. Zamyatin, A.I. Shafranovskaya, O.G. Tarasov, V.A. Penkin, N.A. Zinin, V.I. Lobanov, Yu.V. Gusakov, I.I. Donguzov, M.O. Shitinkov, V.I. Kolesnikov, V.A. Kireev, A.A. Mudrokh

DLNP

I.N. Meshkov, A.G. Olshevskiy, Z.V. Krumshstein

LIT

V.V. Ivanov, P.G. Akishin, P.I. Kisel, O.Yu. Derenovskaya, Zh.Zh. Musulmanbekov, A.M. Raportirenko, P.V. Zrelov

FLNP

E.I.Litvinenko

11. **Design and construction of the superconducting solenoidal and magnet yoke**

**A.S. Vodopyanov**

R&D Technical proposal
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VBLHEP

G.D. Kekelidze, V.I. Lobanov, S.G. Gordeev, A.A. Efremov, Yu.Yu. Lobanov, V.H. Dodokhov, E.M. Kislov, N.D. Topilin

12. **Design and creation of the read-out and slow control system**

**S.V. Bazylev**

Project preparation Realization
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VBLHEP

V.M. Slepnev, I.V. Slepnev, A.E. Baskakov, V.Yu. Rogov, A.B. Shutov, A.V. Shchipunov, N.A. Shutova, R.V. Nagdasev, S.V. Sergeev, A.F. Mukhatnabaev

13. **Preparation of the physical program and SPD detector project for studying of the spin effects at NICA complex**

**I.A. Savin  
A.D. Kovalenko  
V.V. Kukhtin**

Project preparation Realization
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VBLHEP

A.P. Nagaytsev, G.V. Meshcheryakov, A.I. Zinchenko, E.V. Zemlyanichkina, N.S. Rogacheva, Yu.I. Ivanshin,

	D.V. Peshekhonov, V.V. Myalkovsky, A.V. Ivanov, N. Dzhavadov, O.M. Kuznetsov, A.I. Malakhov, B. Marineva, F. Ahmadov, R.R. Akhunzyanov, G.I. Smirnov, E.A. Strokovsky, R. Lednický, S.S. Shimansky, N.D. Topilin, V.P. Ladygin, P.K. Kurilkin, A.K. Kurilkin, V.A. Anosov, A.A. Baldin, A.P. Cheplakov, I.A. Golutvin, I.P. Yudin		
DLNP	Z.V. Krumshtein, R. Abramishvili, A.V. Guskov, I.A. Orlov, N.V. Anfimov, I.E. Chirikov-Zorin, I.B. Gongadze, A.L. Gongadze, M. Finger(junior), M. Finger, M. Slunetchka, V. Slunetchkova, N.B. Skachkov, G.A. Shelkov		
LIT	T.A. Strizh, V.V. Palchik		
BLTP	A.V. Efremov, O.V. Teryaev, G.A. Kozlov, A.V. Radyushkin, A.V. Sidorov, Yu.I. Uzikov		
<b>14. Development of computer infrastructure for NICA complex</b>	<b>Yu.K. Potrebenikov</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Realization</td></tr></table> <b>O.V. Rogachevsky</b>	Realization	
Realization			
VBLHEP	B.G. Schinov, Yu.I. Minaev, V.L. Svalov, V.F. Dydyshko, D.T. Madigozhin, N.A. Molokanova, D.V. Peshekhonov, I.A. Polenkevich, S.N. Shkarovsky		
LIT	D.V. Kekelidze, V.V. Korenkov, M.S. Plyashkevich		
<b>15. Technical design and development of the engineering infrastructure of Nuclotron–NICA</b>	<b>I.N. Meshkov</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Projecting</td></tr></table> <b>G.V. Trubnikov</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Realization</td></tr></table> <b>A.V. Dudarev</b>	Projecting	Realization
Projecting			
Realization			
VBLHEP	N.D. Topilin, A.V. Shabunov, E.V. Serochkin, A.A. Makarov, N.V. Semin, V.M. Stepanov, A.M. Karetnik, V.P. Chernyaev, A.N. Sotnikov, V.Yu. Shilov, M.I. Migulin, A.V. Alfeev, O.M. Timoshenko		
DLNP	S.L. Yakovenko		
LRB	G.N. Timoshenko		
OCE	G.D. Shirkov, V.N. Buchnev + 2 pers.		
AS&CC Office	L.I. Tikhomirov, Yu.N. Balandin, I.S. Frolov		
GA&C	Yu.N. Denisov		
<b>16. Works on realization of the experiment Baryonic matter at Nuclotron (BM@N)</b>	<b>M.N. Kapishin</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Realization</td></tr></table> <b>V.I. Yurevich</b> <b>O.V. Rogachevsky</b>	Realization	
Realization			
VBLHEP	H.U. Abraamyamyan, S.V. Afanasiev, G.N. Agakishiev, G.S. Averichev, V.A. Babkin, V.P. Balandin, S.N. Bazylev, M.G. Buryakov, D.N. Bogoslovsky, V.A. Balandin, V. Bekirov, I.V. Boguslavsky, P. Batyuk, D.K. Dryablov, B.V. Dubinchik, D.S. Egorov, D.S. Erin, Yu.I. Fedotov,		

J. Fedorishin, I.A. Filippov, O.P. Gavrischuk, K.V. Gertsenberger, S.V. Gertsenberger, V.M. Golovatyuk, Z.A. Igamkulov, V.Yu. Karjavin, V.N. Karpinsky, R.R. Kattabekov, V.D. Kekelidze, G.D. Kekelidze, S.V. Khabarov, V.I. Kireev, Yu.T. Kiryushin, M.Yu. Kozhin, E.S. Kokoulina, V.I. Kolesnikov, A.O. Kolesnikov, A.D. Kovalenko, V.G. Krivokhizhin, A.S. Kuznetsov, N.A. Kuz'min, E.A. Ladygin, V.V. Lenivenko, A.N. Livanov, A.G. Litvinenko, S.P. Lobastov, V.M. Lysan, A.M. Makan'kin, A.I. Maksimchuk, A.I. Malakhov, K.Z. Mamatkulov, S.P. Merts, I.I. Migulina, A.N. Morozov, Yu.A. Murin, S.N. Nagorny, D.N. Nikitin, V.A. Nikitin, V.F. Peresedov, Yu.P. Petukhov, S.M. Piyadin, Yu.K. Potrebenikov, V.Yu. Rogov, P.A. Rukoyatkin, I.A. Rufanov, M.M. Rumyantsev, D.G. Sakulin, S.V. Sergeev, W. Scheinast, R.A. Shindin, A.V. Shutov, V.B. Shutov, V.A. Sitnikov, I.V. Slepnev, V.M. Slepnev, I.P. Slepov, A.S. Sorin, V.N. Spaskov, E.A. Stokovsky, S.Ya. Sychkov, B.V. Sykhov, S.N. Tanyildizi, O.G. Tarasov, A.V. Terletsky, V.V. Tikhomirov, N.D. Topilin, I.A. Tyapkin, V.A. Vasendina, N.M. Vladimirova, S.E. Vasiliev, A.S. Yukaev, V.I. Yurevich, N.I. Zamiatin, A.I. Zinchenko, A.I. Zinchenko, L.S. Zolin, V.V. Ustinov, E.V. Zubarev, A.E. Baskakov, V. Bekirov, D. Dabrovski, A.V. Dmitriev, P.O. Dulov, V.A. Petrov, K. Roslpn, I.V. Kruglova, A.V. Schipunov, N.A. Tarasov, V.O. Sudorenko, S.N. Kukhlin, R.V. Nagdasev, P.S. Geraksiev, M.A. Ilieva, L.S. Jordanova, D.A. Suvarieva, V.I. Yurevich, A.A. Timoshenko, G.A. Yarygin

LIT

D.A. Baranov, N. Voytishin, G.J. Musulmanbekov, V.V. Palchik

DLNP

E.M. Kulish

FLNP

E.I. Litvinenko

BLTP

O.V. Teryaev

**17. Diagnostics of heavy ion beams at the accelerator complex of VBLHEP**

**A.I. Malakhov  
P.I. Zarubin**

Preparation Data taking Data analysis
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VBLHEP

V.V. Rusakova, V. Bradnova, D.A. Artemenkov, A.A. Zaytsev, N.K. Kornegrutsa, R.R. Kattabekov, K.Z. Mamatkulov, P.A. Rukoyatkin

**Collaboration**

**Country or International Organization**

**City**

**Institute or Laboratory**

Armenia

Yerevan

YSU

Azerbaijan

Baku

IP ANAS

Belarus

Minsk

INP BSU

JIPNR-Sosny

NASB

		SPMRC NASB
		“Planar”
		BSUIR
		PTI NASB
	Gomel	GSU
		GSTU
Bulgaria	Sofia	INRNE BAS
		ISSP BAS
		TU-Sofia
		LTD BAS
	Blagoevgrad	SWU
	Plovdiv	PU
CERN	Geneva	CERN
China	Beijing	“Tsinghua”
Czech Republic	Liberec	TUL
	Prague	CU
	Vitkovice	VHM
France	Nantes	SUBATECH
Egypt	Cairo	ECTP
Germany	Darmstadt	GSI
	Dresden	ILK
	Giessen	JLU
	Erlangen	FAU
	Frankfurt/Main	Univ.
		FIAS
	Mainz	JGU
	Regensburg	UR
	Jülich	FZJ
Japan	Nagoya	Nagoya Univ.
Georgia	Tbilisi	AIP TSU
		GTU
Italy	Turin	INFN
	Brescia	Forgiatura
		Morandini
	Genova	ASG
Israel	Tel Aviv	TAU
	Jerusalem	HUJI
Moldova	Chişinău	MSU
		IAP ASM
Poland	Chorzow	Franko-Term
	Warsaw	IEL
		WUT
	Wroclaw	ILT&SR PAS
	Lublin	UMCS
	Otwock-Swierk	NCBJ

Romania	Bucharest	INOE2000 IFIN-HH INCDIE ICPE-CA
Russia	Moscow	LPI RAS ITEP MSU Cryogenmash Geliymash NRC KI NNRU "MEPhF" IBMP RAS
	Moscow, Troitsk	INR RAS
	Belgorod	BelSU
	Gatchina	PNPI
	Dubna	PELCOM Progresstech
	Kazan	Compressormash Spetshmash
	Novosibirsk	BINP SB RAS
	Protvino	IHEP
	St. Petersburg	Neva-Magnet KRI SPbSU
	Syktyvkar	DM Komi SC UrB RAS
	Tomsk	NPI TPU
	Fryazino	ISTOK
Slovakia	Bratislava	IMS SAS
	Košice	PJSU
	Žilina	UŽ
South Africa	Cape Town	UCT
	Johannesburg	UJ WITS
Sweden	Stockholm	SU
	Uppsala	TSL
Ukraine	Kiev	BITP NASU
	Kharkov	KhNU KFTI LTU
USA	Batavia, IL	Fermilab
	Upton, NY	BNL
	Stony Brook, NY	SUNY

## Advanced Studies on Systems of New-Generation Accelerators and Colliders for Fundamental and Applied Research

**Leader:** G.D. Shirkov  
**Deputy:** J.A. Budagov

### Participating Countries and International Organizations:

Armenia, Belarus, Bulgaria, CERN, Czech Republic, Germany, Georgia, Greece, Italy, Japan, Poland, Russia, Slovakia, South Africa, United Kingdom, Ukraine, USA.

### Scientific Programme

JINR participation in international collaborations for the design, creation and improvement of new generation accelerators and colliders by scientific researches and experimental development in the field of particle accelerators physics: design of cryomodules and accelerating structures with superconducting cavities; studies of free electron laser physics, development and construction of diagnostic and accelerator systems applied for ultra short dense bunches in the linear electron accelerators; development and construction of systems applied for formation and diagnostics of ultra short dense bunches in the linear electron accelerators; construction of test facilities for accelerating structures investigation; development and creation of a new generation instrumentation for precision laser metrology of accelerators and detector complexes to increase their luminosity and work parameters. Common investigations in the field of laser-plasma accelerators. On a base of electron linac bench: construction of the stand for calibration of electromagnetic calorimeters and investigations of other detectors and their characteristics; creation of complex for the laboratory and practical trainings of students and PhD students - future engineers from JINR member states.

#### Expected main results in 2017:

- Injector photogun beam dynamics modeling and optimization. Fabrication and investigation of the “transparent” thin-film. Photoinjector prototype commissioning (80–100 keV).
- Optimization of the Linac-200 beam parameters at 200 MeV energy. Design of the UV FEL vacuum beamline and magnet system. Beam extraction into atmosphere for detector parameters investigation, design and manufacturing of beam parallel transfer system (LNP program) after 2-nd, 3-nd and 4-th accelerating station. Mounting of the waveguide RF switch for VARIAN klystron. Work on reconstruction and modernization of the control and interlock systems.
- The final phase R&D’s on compact vacuumed two-coordinates Precision Laser Inclinator with 1 nrad resolution. Designing and construction of prototype of Absolute Distance Meter with 1  $\mu\text{m}$  resolution for distances of 1–10 m. R&D’s for 150 meter long Laser Fiducial Line with possibility of simultaneous measurements of space coordinates of 6 points on the object controlled with 10  $\mu\text{m}$  precision (the nondestructive control).
- Development of education program on the base on working with real Linac-200 equipment for students and PhD students – future engineers from JINR member states; laboratory and practical trainings at Linac-200 accelerator.
- Investigation of electron beam and FEL physics: generation of infrared radiation from JINR undulator at FLASH and measurements of longitudinal bunch profile on basis of this radiation; diagnostic of electron bunches at FLASH2 by using of microchannel plate detectors; test experiments with XFEL microchannel plate detectors on synchrotron sources PETRA III, experimental investigations of 3D ellipsoidal shape electron bunches in PITZ with new laser system.



- Preparation of the proposal of the JINR participation in international collaborations on the design study of future high-energy colliders.

### List of projects:

Project	Leader	Priority (period of realization)
1. Design, construction and test of prototype elements for New-generation accelerators and colliders for fundamental and applied purposes.	G.D. Shirkov G.V. Trubnikov	1 (2016 – 2018)
2. Precision laser metrology for accelerators and detector complexes	Yu.A. Budagov M.V. Lyablin	1 (2016 – 2018)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. <b>Construction of the photoinjector prototype based on DC accelerating structure integrated into electron gun with the “transmissive” photocathode and laser driver of the picosecond range</b>  VBLHEP	N.I. Balalykin M.A. Nozdrin  V.F. Minashkin, V.G. Shabratov, A.V. Shevelkin, G.V. Trubnikov	Technical proposal Realization
2. <b>Electron beam test bench based on the linear accelerator with the energy up to 200 MeV for accelerating structures properties investigations, FEL R&amp;D, semi-conducting structures investigation aimed on new detectors parameters improvement, radiation hardness of GaAs detectors testing and other applied research</b>  VBLHEP  DLNP  UC	G.D. Shirkov V.V. Kobets M.A. Nozdrin  V.G. Shabratov, A.V. Skrypnik, A.N. Ukhanov, V.F. Minashkin  A.M. Artikov, J.A. Budagov, Yu.I. Davidov, V.N. Duginov, V.V. Glagolev, E.M. Syresin, M.I. Gostkin, P.I. Smolyansky, S.Yu. Porokhovoy  S.Z. Pakulyak	Technical proposal Realization
3. <b>R&amp;D’s on high-precision Laser metrology of the spatial position of the accelerators units including ground motion monitoring for colliders luminosity maintenance</b>	Yu.A. Budagov M.V. Lyablin	Technical proposal Realization

DLNP

N.S. Azaryan, V.Yu. Batusov, Yu.I. Davidov, D.L. Demin,  
V.V. Glagolev, V.I. Kolomoets, S.M. Kolomoets,  
A.A. Pluzhnikov, V.M. Romanov, B.M. Sabirov,  
A.V. Sazonova, S.N. Studenov, A.K. Sukhanova,  
G.T. Torosyan

VBLHEP

G.V. Trubnikov, G.D. Shirkov

4. **Construction of the education bench for accelerator, RF and vacuum technics practice at the Linac-200 accelerator, preparation of the corresponding education programs and teaching materials**

**A.S. Zhemchugov  
M.A. Nozdrin  
K.B. Gikal**

Technical proposal  
Realization

UC

D.A. Zlydenny, D.S. Shvidky

5. **Investigation on intense electron beams and FEL. Development and construction of diagnostic and accelerator systems applied for ultra-short dense bunches in the linear electron accelerators**

**E.M. Syresin  
O.I. Brovko  
M.V. Yurkov**

Realization

DLNP

N.A. Morozov, A.F. Chesnov, R.S. Makarov, D.S. Petrov,  
V.M. Romanov

VBLHEP

A.Yu. Grebentsov, O.A. Myslinskaya

6. **Preparation of the proposal of the JINR participation in the FCC design study at CERN. Preparation of the proposals of JINR participation in international collaborations for future high energy colliders**

**G.D. Shirkov  
G.V. Trubnikov**

Preparation

## Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	ANSSP Shirak Technologies
	Garni	GGO
Belarus	Minsk	BSUIR SPMRC NASB PTI NASB
		INP BSU
Bulgaria	Sofia	INRNE BAS
CERN	Geneva	CERN
Czech Republic	Prague	CTU
Germany	Darmstadt	GSI
	Hamburg	DESY

	Heidelberg	MPIK
	Zeuthen	DESY
Georgia	Tbilisi	HEPI-TSU
Greece	Athens	UoA
Italy	Pisa	INFN
	Frascati	INFN LNF
	Genova	INFN
Japan	Tsukuba	KEK
Poland	Krakow	NINP PAS
Russia	Moscow	SSDI
		NNRU "MEPhI"
	Moscow, Troitsk	INR RAS
	Nizhny Novgorod	IAP RAS
	Novosibirsk	BINP SB RAS
	Ryazan	RSU
	Sarov	VNIEF
Ukraine	Kiev	PEWI NASU
	Kharkov	IERT NASU
United Kingdom	Oxford	JAI
South Africa	Cape Town	iThemba LABS
Slovakia	Bratislava	IEE SAS
USA	Upton, NY	BNL
	Batavia, IL	Fermilab

## Study of Polarization Phenomena and Spin Effects at the JINR Nuclotron-M Facility

**Leader:** A.D. Kovalenko

**Deputies:** N.M. Piskunov  
V.P. Ladygin  
M. Finger (Jr.)  
R.A. Shindin

### Participating Countries and International Organizations:

Belarus, Bulgaria, CERN, Czech Republic, France, Germany, Japan, Poland, Romania, Russia, Slovakia, Sweden, Switzerland, Ukraine, United Kingdom, USA, Uzbekistan.

### Scientific Programme

Methodical support of the experiments at polarized beams of the Nuclotron-M and NICA facilities, including development of polarimetry systems. Measurement of analyzing power for the reaction  $p + CH_2$  at polarized proton momentum up to 7.5 GeV/c and polarized neutrons momentum 4.5 GeV/c at the setup ALPOM-2. Measurement of tensor analyzing power and spin correlation in  $d \rightarrow p$  reaction in the deuteron core area with the use of polarized  $^3He$  target and polarized deuteron beam of the Nuclotron-M. Study of 2N- and 3N-correlations in deuteron-proton elastic scattering and deuteron break-up reactions at the Nuclotron internal target. Works on modernization of Saclay-Argonne-JINR polarized proton target (setup PPT). The analysis of set of the  $np$  spin observables at  $0^\circ$  (the total  $np$  cross section differences), using polarized targets and quasi-monochromatic relativistic 1.2-3.6 GeV neutron beams. Determination of the forward scattering  $NN$  amplitudes over this energy region. Comparison of the obtained data with QCD motivated model calculations. Study of charge-exchange processes in  $dp$ -interactions at the setup STRELA. Development of theoretical models for description of the simplest nuclear systems taking into account relativistic effects, meson and quark-gluon components of the internal movement. Theoretical analysis of experimental data obtained at Nuclotron-M. The study of the properties of strongly interacting matter utilizing polarization phenomena in hadron-nucleon and lepton-nucleon interactions, and in the decay of polarized radioactive atomic nuclei. Study of highly excited nuclear matter and collective effects in nuclear media; delta and other nucleonic resonance excitations on protons and nuclei. Preparation of the setup DELTA-LNS and data taking on the light neutral mesons production in polarized nucleons and nucleus interactions.

### Expected main results in 2017:

- Works:
  - a) study of low energy proton and deuteron polarimeter within the frames of the program: "Spin Physics Research Infrastructure at the Nuclotron";
  - b) preparation to the measurements of analyzing power of neutron-CH scattering at polarized neutron momentum from 3 to 4.5 GeV/c.
- Completion of stages of the approved projects and collaborative protocols within the frames of their real financial support, including:
  - a) realization of the projects ALPOM-2 and DSS;
  - b) experiments at the setup ALPOM-2 analysis of the collected data from DELTA-SIGMA setup.
- Participation in the design and construction of BM@N setup in accordance with general plan.
- Participation in the joint scientific programs and experiments, design and test of the new detectors and electronics for the use at SPS LHC, FCC (CERN), RHIC (BNL), TJNAF (Newport News), FAIR (GSI) in accordance with the approved collaborative agreements.

- Continuation of the development of the new methods to calculation of the amplitudes and polarization characteristics of deuteron fragmentation and deuteron elastic scattering on protons and nuclei taking into account FSI and relativistic effects.

### List of projects:

Project	Leader	Priority (period of realization)
1. ALPOM-2	N.M. Piskunov	1 (2010 – 2018)
2. DSS	V.P. Ladygin A.I. Malakhov T. Yesaka	1 (2010 – 2018)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Works on the development: of spin physics research infrastructure at the Nuclotron and other facilities	<b>A.D. Kovalenko</b>	Realization
VBLHEP	V.P. Ladygin, S.G. Reznikov, P.K. Kurilkin, S.M. Piyadin, Yu.V. Gurchin, V.V. Glagolev, V.I. Sharov, A.I. Malakhov, A.P. Nagaytsev, I.A. Savin, A.N. Livanov, R.A. Shindin, V.V. Fimushkin, A.M. Taratin	
BLTP	V.V. Burov, V.K. Lukyanov, A.V. Efremov, O.V. Teryaev	
DLNP	M. Finger, M. Finger (Jr.)	
LIT	R.V. Polyakova	
2. ALPOM-2 Project	<b>N.M. Piskunov</b> <b>E. Tomasi-Gustafsson</b> <b>C.F. Perdrisat</b> <b>V. Punjabi</b>	Data taking
VBLHEP	V.V. Glagolev, I.M. Sitnik, A.A. Povtoreyko, Yu.P. Bushuev, D.A. Kirillov, P.A. Rukoyatkin, O.P. Gavrishchuk, S.N. Bazylev, A.D. Kovalenko, R.A. Shindin, A.N. Livanov	
3. DSS Project	<b>A.I. Malakhov</b> <b>V.P. Ladygin</b> <b>T. Yesaka</b>	Preparation Data taking
VBLHEP	S.G. Reznikov, P.K. Kurilkin, S.M. Piyadin, Yu.V. Gurchin, A.A. Terekhin, Yu.-T. Karachuk, A.N. Livanov, A.N. Khrenov, N.B. Ladygina, A.P. Ierusalimov, A.Yu. Isupov	
DLNP	G.I. Lykasov	
4. Modernization of the polarized proton target infrastructure (setup PPT)	<b>N.S. Borisov</b> <b>R.A. Shindin</b>	Preparation Data taking
VBLHEP	R.A. Shindin	

	DLNP	Yu.A. Usov, Yu.A. Plis, N.A. Bazhanov, A.N. Fedorov	
5. Development of the Delta–Sigma program for future experiments at setup BM@N		A.D. Kovalenko V.I. Sharov R.A. Shindin	Data analysis Project preparation
	VBLHEP	E.V. Chernykh, Yu.T. Borzunov, N.A. Kuzmin, I.P. Yudin	
	DLNP	N.S. Borisov, Yu.A. Usov, M. Finger, M. Finger (jr.), E.I. Bunyatova, M. Slunečhka, V. Slunečhkova	
	FLNP	S.B. Borzakov, Ts. Panteleev	
	LIT	R.V. Polyakova	
6. Experiments on the program STRELA		N.M. Piskunov	Data taking Data processing
	VBLHEP	V.V. Glagolev, I.M. Sitnik, Yu.P. Bushuev, A.A. Povtoreyko, D.A. Kirillov, S.N. Bazylev	
7. Theoretical calculations of polarized processes		V.V. Burov V.K. Lukyanov	Data analysis
	BLTP	V.V. Burov	
	VBLHEP	N.B. Ladygina, A.P. Ierusalimov	
8. Spin effects in hadron-nucleon and lepton-nucleon interactions		M. Finger	Data analysis
	DLNP	E.I. Bunyatova, M. Slunečhka, V. Slunečhkova, M. Finger (Jr.)	
9. Works on the program DELTA–2 (INR RAS - JINR)		A.B. Kurepin A.N. Livanov	Preparation Data taking
	VBLHEP	S.N. Bazylev, A.P. Ierusalimov, V.P. Ladygin, Yu.S. Anisimov, S.M. Piyadin	

## Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	INP BSU
Bulgaria	Sofia	UCTM
CERN	Geneva	CERN
Czech Republic	Prague	CU
		CTU
	Brno	ISI ASCR
	Liberec	TUL
	Řež	NPI ASCR
France	Saclay	IRFU
	Orsay	IPN Orsay
Germany	Dresden	TU Dresden
	Bochum	RUB
	Jülich	FZJ

Japan	Tokyo	UT
	Hiroshima	Hiroshima Univ.
	Osaka	RCNP
Poland	Otwock-Swierk	NCBJ
Romania	Bucharest	INC DIE ICPE-CA
Russia	Gatchina	PNPI
	Moscow	LPI RAS
		NRC KI
	Moscow, Troitsk	INR RAS
Slovakia	Bratislava	IP SAS
	Košice	IEP SAS
		PJSU
	Žilina	UŽ
Sweden	Uppsala	TSL
Switzerland	Geneva	UniGe
	Villigen	PSI
Ukraine	Kharkov	KFTI
United Kingdom	Glasgow	U of G
USA	Upton, NY	BNL
	Newport News, VA	JLab
	Norfolk, VA	NSU
	Williamsburg, VA	W&M
Uzbekistan	Tashkent	INP AS RUz
		Assoc. "P.-S." PTI

## Research on Relativistic Heavy and Light Ion Physics. Experiments at the Nuclotron, SPS and SIS18

**Leader:** A.I. Malakhov  
**Deputy:** S.V. Afanasiev

### Participating Countries and International Organizations:

Armenia, Bulgaria, CERN, China, Czech Republic, France, Germany, Japan, India, Kazakhstan, Mongolia, Poland, Romania, Russia, Slovakia, Sweden, Switzerland, Tajikistan, USA, Uzbekistan.

### Scientific Programme

#### Scientific Programme

Search for manifestation of quark-gluon degrees of freedom in collisions of relativistic nuclei and phase transitions in nuclei and exotic resonances. Study of nuclear multifragmentation processes. The Nuclotron internal target experiments. Asymptotics in nuclear collisions and nucleon clusters. Detector development for relativistic heavy-ion experiments at the CERN and BNL. Investigation of the interactions of nuclei at energy 20-158 GeV on a nucleon on NA61/SHINE experiment (SPS, CERN). Study of hadron production in hadron-nucleus interactions. Use of these data for precise predictions of neutrino fluxes in neutrino oscillation experiments at accelerators. Study of fragmentation of light stable and radioactive nuclei with beams of secondary nuclei and data analysis. Studies of cluster structure of light stable and radioactive nuclei in relativistic dissociation. Studies of multifragmentation of heavy nuclei. Study of the properties strong interaction matter. Study of the particles properties in nuclear matter at the Nuclotron.

#### Expected main results in 2017:

- Continuation of experiments with the internal target at the Nuclotron. Preparation and carrying out of experiments with extracted beams at the Nuclotron. Development of the software for modeling and processing experimental data.
- Participation in realization NA61. Study of hadron production in proton-carbon interactions at 30 GeV in the NA61/SHINE experiment at CERN. Use of these data for improved predictions of neutrino fluxes and precise determination of neutrino oscillation parameters in the T2K experiment in Japan.
- Experimental study of the properties of hot nuclei produced in the collisions of the light relativistic projectiles with heavy target. Measuring and analysis of the longitudinal versus transversal velocity components of fragments in order to understand the degree of the equilibration involved in the disassembly process. The elaboration of the trigger system for decay registration of hypernuclei.
- Study of multiparticle dynamics in terms of masses and energies of colliding objects and centrality of interaction. Mathematical modeling of experiments on investigation of the properties of highly excited states of nuclear matter in relativistic nuclear collisions and the mechanism of quark hadronization in the process of pion pair production.
- Search for eta-mesic nuclei formed in  $dA$  collisions, the determination of the total cross section of eta-nucleus production in  $dA$  collisions and its energy and A-dependence, the construction and production of the neutron detector for this experiment. Investigation of scintillators at high beam intensity.
- Preparation of the physical programme for experiments at SIS18 and SIS100.
- Analysis of nuclear track emulsion exposed to the isotopes B-10 and C-11. Exposure of emulsion in secondary beam of the radioactive isotope Be-10. Exposures to heavy nuclei. Test exposures of emulsion in range of hundreds MeV per nucleon.



- Study of nuclear interactions depending on projectile mass and energy with the beams of relativistic nuclei at the Nuclotron and other accelerators with the photo-emulsion method. Study of fragmentation, multifragmentation, multiparticle production together with correlations between them at interaction of nuclei of various energies with photo-emulsion nuclei. Search for collective effects in central nuclear-nuclear collisions in photo-emulsions.
- Search and study of new phenomena based on the data obtained using bubble chambers; Theoretical interpretation of these results. Creation of the data base of experimental data and educational programs in the field of relativistic nuclear physics.
- Study of deep subthreshold processes, applied and educational programs at MARUSYA setup. Construction of electromagnetic detector of MARUSYA setup and test channel and corresponding electronics for detector testing.
- Investigations with light and heavy ions for applied research.
- Elaborate schemes of measurement and experimental study (energy and time resolution) of the hadron calorimeter, designed to monitor and measure the luminosity at the collider NICA, and the neutron detector, designed for the study of nuclear structure isospin internucleonic on small distances. It uses beam-formed channel 4B and installing infrastructure of the SPHERE setup.

### List of projects:

Project	Leader	Priority (period of realization)
1. NA61	A.I. Malakhov	1 (2012 – 2017)
2. FASA-3	S.P. Avdeev	1 (2013 – 2017)
3. SKAN-3	S.V. Afanasiev A.I. L'vov	1 (2017 – 2019)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Experiment NA61/SHINE	A.I. Malakhov G.L. Melkumov	Data taking Preparation Data analysis
VBLHEP	D.A. Artyemenkov, D.K. Dryablov, A.Yu. Isypov, V.I. Kolesnikov, V.A. Kireev	
DLNP	B.A. Popov, S.A. Bunyatov	
2. Experiment BECQUEREL	P.I. Zarubin	Data taking
VBLHEP	V.V. Rusakova, D.A. Artemenkov, V. Bradnova, A.A. Zaytsev, N.K. Kornegrutsa, P.P. Kattabekov, L.Z. Mamatkulov, P.A. Rukoyatkin	
3. Project FASA-3	S.P. Avdeev	Preparation Data taking
DLNP	V.V. Kirakosyan, W. Kartch	
FLNR	G.V. Mushinsky, O.V. Strekalovsky, V.I. Stegaylov	
VBLHEP	P.A. Rukoyatkin	

4. Project SCAN-3

S.V. Afanasiev  
A.I. L'vov

Preparation  
Data taking  
Upgrade

VBLHEP

Yu.S. Anisimov, B.V. Dubinchik, V. Berikov, A.F. Elishev,  
Z.A. Igamkulov, D.K. Dryablov, L.V. Korniyushina,  
Yu.F. Krechetov, A.S. Kuznetsov, D.G. Sakulin,  
V.A. Smirnov, E.V. Sukhov, V.V. Ustinov

5. Search and investigation of new phenomena using information obtained with bubble chambers and their theoretical interpretation. Creation of data base of experimental data and educational programs in the field of relativistic nuclear physics

A.A. Baldin  
V.V. Glagolev

Data analysis

VBLHEP

A.V. Belyaev, V.V. Ilyushchenko, A.Yu. Troyan,  
A.P. Ierusalimov, S.G. Arakelyan, O.V. Rogachevsky,  
S.G. Stetsenko

6. Investigation of deep subthreshold processes, applied and educational programs at MARUSYA set up

A.A. Baldin

Preparation  
Data taking

VBLHEP

V.A. Arefiev, S.V. Afanasiev, A.V. Belyaev, B.N. Guskov,  
I.V. Kudashkin, A.I. Kudashkin, I.V. Slepnev,  
S.G. Stetsenko, A.Yu. Troyan, A.V. Shabunov,  
S.S. Shimansky, I.P. Yudin, E.E. Perepelkin, I.G. Voloshina,  
T.V. Shavrina

BLTP

V.V. Burov, S.G. Bondarenko

7. Investigation with light and heavy ions for applied research

A.I. Malakhov

Realization  
Preparation  
Data taking

VBLHEP

N.N. Agapov, Yu.S. Anisimov, A.D. Kovalenko,  
A.A. Baldin, V.S. Butsev, D.K. Dryablov

8. Upgrade of equipment the station of internal target of the Nuclotron

S.V. Afanasiev

Upgrade  
Data taking

VBLHEP

Yu.S. Anisimov, B.V. Dubinchik, V. Bekirov, A.F. Elishev,  
Z.A. Igamkulov, D.K. Dryablov, A.S. Kuznetsov,  
S.N. Kuznetsov, D.G. Sakulin, T.V. Trofimov

9. Test of the detectors for measurements and control the luminosity at the collider NICA, and detectors for the study of nuclear structure at small internucleon distances

A.G. Litvinenko  
A.B. Kurepin

R&D  
Technical proposal

VBLHEP

I.I. Migulina, V.F. Peresedov, V.I. Shokin, L.S. Zolin, O.P. Gavrischuk, N.A. Kuzmin, E.A. Ladygin, S.Ya. Sychkov, Yu.P. Petukhov, E.A. Usenko, D.S. Erin, A.I. Yukaev, S.N. Nagorny, V.P. Balandin

**Collaboration**

<b>Country or International Organization</b>	<b>City</b>	<b>Institute or Laboratory</b>
Armenia	Yerevan	Foundation ANSL YSU
Bulgaria	Sofia	INRNE BAS
CERN	Geneva	CERN
China	Beijing	IHEP CAS CIAE CCNU
Czech Republic	Wuhan Prague Řež	IMC ASCR NPI ASCR
France	Orsay	IPN Orsay
Germany	Darmstadt	TU Darmstadt GSI HZDR
	Dresden	Univ.
	Frankfurt/Main	JLU
	Giessen	Univ.
	Heidelberg	TUM
	Munich	Univ.
	Siegen	RCNP
Japan	Osaka	UT
	Tokyo	Univ.
	Tsukuba	Univ.
India	Jaipur	BARC
	Mumbai	IPT
Kazakhstan	Almaty	IPT MAS
Mongolia	Ulaanbaatar	NEC
Poland	Krakow	NINP PAS
	Lodz	UL
	Otwock-Swierk	NCBJ
	Warsaw	WUT
Romania	Bucharest	UB IFIN-HH INCDIE ICPE-CA ISS
	Constanța	UOC
Russia	Moscow	SINP MSU LPI RAS ITEP
	Moscow, Troitsk	INR RAS
	Chernogolovka	ISMAN RAS

	Smolensk	SSU
	St. Petersburg	FIP
	Sarov	VNIIEF
	Tomsk	TPU
Slovakia	Bratislava	IP SAS
	Košice	PJSU
Sweden	Lund	LU
Switzerland	Villigen	PSI
	Geneva	UniGe
	Zurich	ETH
Tajikistan	Dushanbe	PHTI ASRT
USA	Berkeley, CA	Berkeley Lab
	Iowa City, IA	UIowa
	Norfolk, VA	NSU
	Upton, NY	BNL
	Williamsburg, VA	W&M
Uzbekistan	Tashkent	Assoc."P.-S." PTI
	Jizakh	JSPI
	Samarkand	SSU

## Investigation of the Properties of Nuclear Matter and Particle Structure at the Collider of Relativistic Nuclei and Polarized Protons

### Leaders:

R. Lednický  
Yu.A. Panebratsev

### Participating Countries and International Organizations:

Armenia, Azerbaijan, Bulgaria, Czech Republic, France, Germany, Poland, Russia, Slovakia, USA.

### Scientific Programme

Investigation of the properties of nuclear matter with extremely high density and temperature, search for the signs of the quark deconfinement and possible phase transitions at the collisions of heavy nuclei at the energies of the Relativistic Heavy Ion Collider (RHIC). Measurement of spin dependent structure functions of nucleons and nuclei using polarized RHIC beams.

#### Expected main results in 2017:

- The data on heavy ion and polarized proton–proton and polarized proton nucleus collisions taken in the STAR experiment at RHIC.
- Beam energy measurement of transverse spin asymmetry in polarized  $pp$  collisions at energy 510 GeV and study of sign change in Sivers function.
- Measurements of event structure, collective variables, correlation characteristics, femtosopic correlation functions and high  $P_T$  processes.
- Measurement of spin depended and gluon structure functions in polarized proton collisions with Al an Au nuclei.
- Participation in JINR–BNL and JINR–CERN joint educational programs.

### List of projects:

Project	Leader	Priority (period of realization)
1. STAR	Yu.A. Panebratsev R. Lednický	1 (2010 – 2018)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Participation in the spin physics program in STAR experiment at RHIC  VBLHEP	Yu.A. Panebratsev	Data taking Data analysis
	M.V. Tokarev, T.G. Dedovich, A.O. Kechechyan, L.G. Efimov, A.N. Zubarev, V.V. Tikhomirov, V.B. Dunin, V.I. Yurevich, D.N. Bogoslovsky, G.A. Yarygin, A.A. Povtoreyko, V.Yu. Rogov, S.V. Sergeev	

2. **The study of polarized proton collisions with nuclei at 200 GeV**  
VBLHEP  
LIT  
BLTP
- M.V. Tokarev Realization  
V.V. Lyuboshits, T.G. Dedovich, A.A. Aparin  
Zh.Zh. Musulmanbekov  
O.V. Teryaev, A.E. Dorokhov, S.V. Goloskokov
3. **The study of event structure, collective effects, femtoscopic correlations and high  $p_T$  processes**  
VBLHEP  
LIT
- R. Lednický Realization  
Yu.A. Panebratsev  
P. Filip, M.V. Tokarev, S. Vokal, A.O. Kechechyan, N.Ya. Tchankova–Bnzarova, T.G. Dedovich, L.G. Efimov, I.Zh. Bnzarov, G.S. Averichev, G.N. Agakishiev, A.A. Aparin, O.V. Rogachevsky  
G.A. Ososkov
4. **Participation in the heavy ion program in STAR experiment at RHIC. Beam–energy scan**  
VBLHEP  
LIT
- Yu.A. Panebratsev Data taking  
Data processing  
Data analysis  
P. Filip, M.V. Tokarev, S. Vokal, A.O. Kechechyan, N.Ya. Tchankova–Bnzarova, T.G. Dedovich, L.G. Efimov, I.Zh. Bnzarov, G.S. Averichev, E.V. Potrebenikova, B.G. Shchinov, G.N. Agakishiev, O.V. Rogachevsky  
V.V. Korenkov, G.A. Ososkov, V.V. Mitsyn
5. **Development of the software and formation of the infrastructure for the STAR data processing at JINR**  
VBLHEP  
LIT
- V.V. Korenkov Realization  
Yu.A. Panebratsev  
E.V. Potrebenikova, A.O. Kechechyan, A.A. Aparin, N.Ya. Tchankova–Bnzarova, G.N. Agakishiev  
N. Balashov, G.A. Ososkov, V.V. Mitsyn, T.A. Strizh
6. **Participation in JINR–BNL and JINR–CERN joint educational programs**  
VBLHEP  
UC
- Yu.A. Panebratsev Realization  
E.V. Potrebenikova  
V.V. Belaga, N.E. Sidorov, K.V. Klygina, M.S. Stetsenko, P.D. Semchukov, A.V. Shoshin, E.I. Golubeva, N.I. Vorontsova, M.P. Osmachko  
S.Z. Pakulyak, I.A. Smirnova, A.O. Komarova, S.N. Balalykin, O.A. Smirnov

## Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL
Azerbaijan	Baku	IRP ANAS
Bulgaria	Sofia	INRNE BAS

Czech Republic	Prague Řež	CU UJV NPI ASCR
France	Nantes	SUBATECH
Germany	Heidelberg	Univ.
Poland	Warsaw	WUT
Russia	Moscow	NNRU "MEPhI"
	Protvino	ITEP
	St. Petersburg	IHEP
Slovakia	Bratislava	SPbSU
	Košice	IP SAS
USA	Berkeley, CA	PJSU
	Bloomington, IN	Berkeley Lab
	Lemont, IL	IU
	Upton, NY	ANL
	New Haven, CT	BNL
	University Park, PA	Yale Univ.
		Penn State

## ALICE. Study of Interactions of Heavy Ion and Proton Beams at the LHC

**Leader:** A.S. Vodopyanov

### Participating Countries and International Organizations:

Armenia, Bulgaria, CERN, China, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, India, Italy, Mongolia, Netherlands, Norway, Poland, Republic of Korea, Romania, Russia, Slovakia, South Africa, Sweden, Switzerland, Ukraine, United Kingdom, USA.

### Scientific Programme

1. Participation in the preparation of ALICE upgrade (Photon spectrometer PHOS, assembly of the setup).
2. Realization of experiments at the LHC.
3. Physics research program at the ALICE detector.
4. Development and upgrade of data analysis computing GRID-ALICE in Russia.

#### Expected main results in 2017:

- Participation in the R&D for the upgrade of photon spectrometer PHOS.
- Participation in the physics project preparation. Physics simulation of heavy ions and protons interactions at LHC energies.
- Data analysis. Preparation of publications.
- Upgrade, testing and supporting of GRID.

### List of projects:

Project	Leader	Priority (period of realization)
1. ALICE	A.S. Vodopyanov	1 (2010 – 2019)
2. R&D for the ALICE Photon Spectrometer	A.S. Vodopyanov	1 (2010 – 2018)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Particle detectors	A.S. Vodopyanov	Realization
VBLHEP	V.I. Astakhov, V.A. Arefiev, V.H. Dodokhov, E.M. Kislov, V.I. Lobanov, P.V. Nomokonov, I.A. Rufanov	
2. Physical process simulation and data analysis	B.V. Batyunya	Realization
VBLHEP	M.Yu. Barabanov, Yu.L. Vertogradova, D.D. Emelyanov,	



S.S. Grigoryan, L.V. Malinina, V.N. Pozdnyakov,  
E.P. Rogochaya, A.V. Taranenko, A.G. Fedunov,  
K.P. Mikhaylov, K. Roslon

DLNP

G.I. Lykasov

LIT

R.M. Yamaleev

BLTP

D. Blaschke, A.V. Sidorov

**3. ALICE. Computing in the distributed environment–GRID**

**A.S. Vodopyanov**

Realization
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VBLHEP

B.V. Batyunya, A.G. Fedunov, G.G. Stiforov

LIT

V.V. Mitsyn

**4. Photon Spectrometer PHOS**

**A.S. Vodopyanov**  
**P.V. Nomokonov**

Realization
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VBLHEP

N.V. Gorbunov, N.A. Kuzmin, Yu.P. Petukhov,  
S.A. Rufanov

**Collaboration**

**Country or International Organization**

**City**

**Institute or Laboratory**

Armenia

Yerevan

Foundation ANSL

Bulgaria

Sofia

SU

CERN

Geneva

CERN

China

Beijing

CIAE

Wuhan

CCNU

Croatia

Zagreb

RBI

Czech Republic

Prague

IP ASCR

Řež

UJV

Denmark

Copenhagen

NBI

France

Clermont-Ferrand

LPC

Lyon

UCBL

Nantes

SUBATECH

Orsay

IPN Orsay

Saclay

IRFU

Strasbourg

CRN

Germany

Darmstadt

GSI

Heidelberg

Univ.

Frankfurt/Main

Univ.

Marburg

Univ.

Münster

Univ.

Greece

Athens

UoA

Hungary

Budapest

Wigner RCP

India

Aligarh

AMU

Bhubaneswar

IOP

Calcutta

VECC

		SINP
	Chandigarh	PU
	Jammu	Univ.
Italy	Bari	INFN
	Bologna	INFN
	Cagliari	INFN
	Catania	UniCT
	Legnaro	INFN LNL
	Padua	INFN
	Rome	INFN
	Salerno	INFN
	Turin	INFN
	Vercelli	UPO
Mongolia	Ulaanbaatar	IPT MAS
Netherlands	Amsterdam	NIKHEF
	Utrecht	UU
Norway	Bergen	UiB
	Oslo	UiO
Poland	Krakow	NINP PAS
	Warsaw	IEL
		WUT
	Otwock-Swierk	NCBJ
Republic of Korea	Gangneung	GWNU
Romania	Bucharest	ISS
Russia	Gatchina	PNPI
	Moscow	ITEP
		NNRU "MEPhI"
		NRC KI
		SINP MSU
	Moscow, Troitsk	INR RAS
	Novosibirsk	BINP SB RAS
	Protvino	IHEP
	Sarov	VNIIEF
	St. Petersburg	FIP
Slovakia	Bratislava	STU
	Košice	PJSU
South Africa	Cape Town	UCT
Sweden	Lund	LU
Switzerland	Lausanne	EPFL
United Kingdom	Birmingham	Univ.
Ukraine	Kharkov	KFTI
	Kiev	BITP NASU
USA	Columbus, OH	OSU
	Oak Ridge, TN	ORNL

## Development and Construction of the Prototype of a Complex for Radiotherapy and Applied Research with Heavy-Ion Beams at the Nuclotron-M

### Leaders:

S.I. Tyutyunnikov

### Participating Countries and International Organizations:

Armenia, Australia, Belarus, Bulgaria, Czech Republic, India, Germany, Greece, Moldova, Mongolia, Poland, Romania, Russia, Serbia, Slovakia, Ukraine.

### Scientific Programme

Investigation of new aspects of electronuclear power engineering and process of energy production and radioactive waste transmutation at various subcritical setups, research of radiation hardness of materials.

#### Expected main results:

- Investigation of physical characteristics of the assemblies, the massive uranium target with a lead reflector – (set-up “Quinta”), the quasi infinite uranium target BURAN with the energy of the proton and deuteron beams of the Nuclotron in the interval from 0.6 up to 12.0 GeV. Receiving data about the multiplicities and special distribution of energy–time neutron spectra. Research on massive targets of natural (depleted) uranium and thorium energy production capabilities and processing of radioactive waste based on the basic principles of relativistic nuclear technologies (RNT), the study of radiation hardness of superconductors by the beams of neutrons and protons.

#### Expected main results in 2017:

- Pilot operation of the neutron spectrometer on recoil protons on the “Quinta” under irradiation with protons and heavy particle beam at the Nuclotron–M and Phazotron.
- Investigation of the efficiency of neutrons generation on heavy ion beams  $Li, C$  on the “Quinta”.
- Installation of a big uranium target on Phazotron, beam adjustment on the target.
- Investigation of impact of high–power laser radiation on the radioactive decay of minor actinides.
- Using of nuclear membrane and track detectors for physics experiments at the Nuclotron–M.

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Development of technical specifications for a quasi infinite uranium target, setting in the DLNP to Phazotron	S.I. Tyutyunnikov A.A. Solnyshkin	Realization
VBLHEP	O.G. Tarasov, I.P. Yudin	
DLNP	I. Adam	

<p>2. Development of the technical specifications for the detector system of setup “big uranium target” on the basis of the temperature sensor and silicon photomultipliers</p> <p>VBLHEP</p> <p>DLNP</p>	<p>S.I. Tyutyunnikov A.A. Solnyshkin</p> <p>A.I. Berlev, Z. Sadygov, A.A. Baldin, I.P. Yudin</p> <p>I. Adam</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Realization</div>
<p>3. Design, manufacture of detectors for the measurement of ion energy in the range of <math>E_e=0.1</math> GeV/nucleon on the Nuclotron–M beams</p> <p>VBLHEP</p>	<p>N.I. Zamyatin</p> <p>O.G. Tarasov, S.V. Khabarov, A.I. Shafranovskaya, Yu.S. Kovalev</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Realization</div>
<p>4. Upgrade of spectrum–analytical complex for activation measurements.</p> <p>VBLHEP</p> <p>DLNP</p>	<p>V.N. Shalyapin</p> <p>M. Paraipan, E.V. Strekalovskaya, I.A. Kryachko</p> <p>V.I. Stegaylov</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Realization</div>
<p>5. The study of neutron fields of big uranium target at the Phazotron under the irradiation of proton <math>E_p=0.66</math> GeV</p> <p>VBLHEP</p> <p>DLNP</p> <p>FLNR</p>	<p>S.I. Tyutyunnikov A.A. Solnyshkin</p> <p>A.I. Berlev, A.A. Baldin, I.P. Yudin, A.V. Vishnesky, T.L. Enik, B. Yuldashev</p> <p>I. Adam, V.I. Stegaylov</p> <p>E.M. Kozulin</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div>
<p>6. The study of influence of high–power coherent radiation at radioactive decay</p> <p>VBLHEP</p>	<p>S.N. Sedykh</p> <p>A.K. Kaminsky, I.A. Kryachko</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div>
<p>7. Production of the monitoring elements for the superconducting systems</p> <p>VBLHEP</p>	<p>Yu.P. Filippov</p> <p>I.D. Kakorin</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">R&amp;D</div>

## Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	YSU
Australia	Sydney	Univ.
Belarus	Minsk	INP BSU JIPNR-Sosny NASB

Bulgaria	Sofia	INRNE BAS
Czech Republic	Řež	UJV
	Brno	BUT
	Prague	CTU
Germany	Darmstadt	TU Darmstadt
	Marburg	Univ.
	Jülich	FZJ
Greece	Thessaloniki	AUTH
India	Mumbai	BARC
	Jaipur	Univ.
Moldova	Chişinău	IAP ASM
Mongolia	Ulaanbaatar	IPT MAS
Poland	Warsaw	WUT
	Krakow	NINP PAS
	Otwock-Swierk	NCBJ
Russia	Moscow	Atomenergomach
	Dubna	BSINP MSU
		IAS "Omega"
	Obninsk	MRRC
		IPPE
	St. Petersburg	KRI
	Tomsk	TPU
Romania	Bucharest	ISS
		UMF
		INCDIE ICPE-CA
	Iaşi	UAIC
Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	SOSMT
		IP SAS
		CU
Ukraine	Kharkov	KFTI
	Uzhgorod	UNU



**Nuclear  
Physics  
(03)**

## Development of the FLNR Accelerator Complex and Experimental Setups (DRIBS-III)

### Leaders:

G.G. Gulbekyan  
S.N. Dmitriev

### Scientific leader:

M.G. Itkis  
Yu.Ts. Oganessian

### Participating Countries and International Organizations:

Belgium, Bulgaria, CERN, China, Czech Republic, Egypt, France, Germany, Italy, Kazakhstan, Mongolia, Poland, Romania, Russia, Serbia, Slovakia, South Africa, Ukraine, Uzbekistan, USA.

### Scientific Programme

The implementation of the DRIBS-III project that includes the upgrade and development of the FLNR cyclotron complex, the expansion of the experimental infrastructure of the laboratory (construction of new physics setups), and the development of the accelerator systems. The project leads to an increase in the operation stability of the accelerators, an increase in the intensity of the ion beams of stable and radioactive nuclides in the energy range from 5 to 100 MeV/nucleon, and an improvement of the quality of the beams with a simultaneous reduction of power consumption. The project aims to significantly improve the efficiency of experiments on the synthesis of superheavy elements and light nuclei at nucleon drip lines and on the study of their properties. Moreover, the programme of experiments with beams of radioactive nuclides is anticipated to be extended.

#### Main results expected in 2017:

- Completion of the construction and commissioning of a new experimental building of the SHE Factory equipped with engineering systems.
- Installation of the equipment and DC-280 cyclotron systems in the experimental hall of the SHE Factory. Pre-commissioning works. Extraction of beams of accelerated heavy ions.
- Construction and commissioning of a gas-filled recoil separator DGFRS-2.
- Commissioning and conducting of test experiments at the new ACCULINNA-2 fragment separator (U-400M cyclotron) using beams of light ions with energies of 30 to 50 MeV/nucleon. Development of the infrastructure of the fragment separator ACCULINNA-2.
- Conducting of experiments with 6-15 MeV/nucleon ion beams at the U-400M cyclotron.
- Production of the intense beams of highly charged ions heavier than Xe using a superconducting ion source and their acceleration in the U-400M cyclotron.
- Implementation of experiments on the synthesis of new isotopes in the region of superheavy elements at the U-400 cyclotron using actinide targets and on the nuclear spectroscopy of heavy ions.
- Development of techniques for the synthesis and radiochemical extraction of radionuclides that have great potential for nuclear medicine and are promising as tracers. Development of equipment and conducting of experiments with beams at the MT-25 microtron.
- Development of new methods of beam diagnostics for stable and radioactive nuclides.
- Construction of a new Gas-cell based Laser-ionization Setup (GALS) for on-line separation of reaction products by selective laser ionization.
- Development of a two-arm mass-spectrometer MAVR.
- Design of separate nodes of the gas ion catcher.



**List of activities:**

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. <b>Construction of a new FLNR experimental hall</b>  FLNR	<b>G.G. Gulbekian</b>	Preparation
	B.N. Gikal, V.A. Kostyrev, N.F. Osipov, P.G. Bondarenko, S.L. Bogomolov, A.V. Reshetov, S.V. Pashenko, M.V. Habarov, I.V. Kalagin, N.Yu. Kazarinov, I.A. Ivanenko, V.A. Verevochkin	
2. <b>Construction of the DC-280 complex</b>  FLNR  VBLHEP	<b>B.N. Gikal</b>	Preparation Data taking
	P.G. Bondarenko, S.L. Bogomolov, A.V. Reshetov, N.F. Osipov, G.N. Ivanov, S.V. Pashenko, M.V. Habarov, I.V. Kalagin, N.Yu. Kazarinov, I.A. Ivanenko, N.N. Pchelkin  A.A. Fateev + 2 pers.	
3. <b>Development of the U-400M and U-400R complexes</b>  FLNR  LIT  DLNP  VBLHEP	<b>B.N. Gikal</b>	Preparation Data taking
	P.G. Bondarenko, S.L. Bogomolov, A.V. Reshetov, N.F. Osipov, G.N. Ivanov, S.V. Pashenko, M.V. Habarov, I.V. Kalagin, N.Yu. Kazarinov, I.A. Ivanenko, R.E. Vaganov, V.A. Sokolov, N.N. Pchelkin  V.V. Korenkov, A.M. Chervyakov, P.G. Akishin, E.A. Airian  G.A. Karamysheva, E.V. Samsonov, S.A. Kostromin, S.B. Vorozhtsov  A.A. Fateev + 2 pers.	
4. <b>Development of the ECR ion sources</b>  FLNR  VBLHEP	<b>S.L. Bogomolov</b>	Preparation
	A.A. Efremov, G.N. Ivanov, A.N. Lebedev, V.V. Behterev, N.Yu. Yazvitskiy, V.N. Loginov, V.E. Vironov, A.E. Bondarchenko, K.I. Kuzmenkov  E.D. Donets, V.M. Drobin, E.E. Donets, S.A. Kostomin	
5. <b>Development of the MT-25 microtron</b>  FLNR	<b>S.V. Mitrofanov</b>	Preparation Data taking
	A.G. Belov, Yu.G. Teterev, N.V. Aksenov, S.V. Pashenko, M.V. Habarov, N.F. Osipov, V.A. Semin	
6. <b>Development of the fragment separator ACCULINNA-2</b>  FLNR	<b>A.S. Fomichev</b>	Preparation
	S.A. Krupko, C.G. Belogurov, A.V. Gorshkov, V.A. Gorshkov, G.M. Ter-Akopian, A.A. Bezbakh, M.S. Golovkov, P.G. Sharov, S.I. Sidorchuk, R.S. Slepnev, G. Kaminsky, V. Chudoba, R. Wolski	

7. <b>Design and construction of a pre-separator for radiochemical studies of SHE</b>	<b>A.G. Popeko</b> <b>N.V. Aksenov</b>	Preparation
FLNR	G.A. Bozhikov, A.V. Sabelnikov, Yu.V. Albin	
8. <b>Construction of the gas catcher</b>	<b>A.M. Rodin</b>	Preparation
FLNR	L. Krupa, A.V. Belozerov, S.A. Yukhimchuk, A.V. Guljaeva, V.S. Salamatin, I. Sivachek, S.V. Stepantsov	
9. <b>Construction of a new gas-filled separator</b>	<b>A.G. Popeko</b>	Preparation
FLNR	O.N. Malyshev, A.I. Svirikhin, A.V. Eremin, A.V. Isaev	
10. <b>Development of the project of a separator based on resonance laser ionization</b>	<b>S.G. Zemlyanoy</b>	Preparation
FLNR	V.I. Zhemenuk, G.V. Myshinskiy, E.M. Kozulin, K.P. Marinova, K.A. Avvakumov	

### **Collaboration**

<b>Country or International Organization</b>	<b>City</b>	<b>Institute or Laboratory</b>
Belgium	Leuven	KU Leuven
	Louvain-la-Neuve	IBA
Bulgaria	Sofia	LTD BAS
CERN	Geneva	CERN
China	Lanzhou	IMP CAS
Czech Republic	Brno	BUT
	Prague	VP
		CTU
		CU
Egypt	Řež	NPI ASCR
	Štěnovice	STREICHER
	Giza	CU
France	Al-Minufya	MU
	Caen	GANIL
Germany	Vannes	SigmaPhi
	Darmstadt	GSI
Italy	Catania	INFN LNS
Kazakhstan	Almaty	INP
	Astana	BA INP
Mongolia	Ulaanbaatar	NRC NUM
Poland	Krakow	NINP PAS
	Warsaw	HIL WU
Romania		IEP WU
	Bucharest	IFIN-HH

Russia	Moscow	N&V ITT-Group ITEP HTDC PNPI IAP RAS BINP SB RAS VNIIEF NIIEFA
	Gatchina	
	Nizhny Novgorod	
	Novosibirsk	
	Sarov	
	St. Petersburg	
Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	IMS SAS IP SAS
South Africa	Cape Town	iThemba LABS
Ukraine	Kiev	KINR NASU
Uzbekistan	Samarkand	SSU
USA	College Station, TX	Texas A&M
	Livermore, CA	LLNL
	Nashville, TN	VU
	Oak Ridge, TN	ORNL

## Synthesis and Properties of Superheavy Elements, Structure of Nuclei at the Limits of Nucleon Stability

**Leader:** M.G. Itkis  
**Scientific leader:** Yu.Ts. Oganessian

### Participating Countries and International Organizations:

Belgium, Bulgaria, CERN, China, Czech Republic, Finland, France, Germany, Egypt, India, Italy, Japan, Kazakhstan, Mongolia, Poland, Romania, Russia, Slovakia, South Africa, Spain, Switzerland, Sweden, Ukraine, United Kingdom, USA.

### Scientific Programme

Synthesis and investigation of the properties of nuclei at stability limits. Investigation of the mechanisms of heavy-ion-induced reactions. Study of physical and chemical properties of heavy and superheavy elements.

#### Main results expected in 2017:

- Carrying out of experiments on the synthesis of heavy isotopes of element 118 (reaction  $^{48}\text{Ca} + ^{249-251}\text{Cf}$ ) and neutron-deficient isotopes of elements Fl and 115 at the gas-filled separator.
- Studies of the decay properties of Rf, Db and Sg isotopes using the separator SHELS + GABRIELA. Preparation of an experiment on the spectroscopy studies of the decay properties of the  $^{288}\text{115}$  isotope and its daughter products. Carrying out of experiments on measurement of the multiplicity of prompt neutrons from the spontaneous fission of Rf and Db isotopes.
- Conducting of experiments on the study of chemical properties of element 113. Conducting of experiments on the study of Cn and Fl selenides.
- Measurement of the excitation functions of the  $xn$  evaporation channels in the complete fusion reactions  $^{40}\text{Ar} + ^{144}\text{Sm}$ ,  $^{40}\text{Ar} + ^{164}\text{Er}$ ,  $^{16}\text{O} + ^{198}\text{Pt}$ , and  $^{18}\text{O} + ^{198}\text{Pt}$ . Study of the yields of products of multi-nucleon transfer reactions in the vicinity of the neutron shell closure  $N = 126$  using the mass-spectroscopic methods.
- Production and study of the properties of new neutron-rich heavy nuclei in binary multi-nucleon transfer processes and quasi-fission. Investigation of the mass-energy distributions of fragments produced in the reactions  $^{160}\text{Gd} + ^{186}\text{W}$ ,  $^{198}\text{Pt}$ ,  $^{52,54}\text{Cr} + ^{232}\text{Th}$ , and  $^{84}\text{Kr} + ^{198}\text{Pt}$ . Study of the multi-body decays of low-excited heavy nuclei.
- Investigation of the structure of the exotic nuclei  $^5\text{H}$ ,  $^{10}\text{Li}$ ,  $^{17}\text{Ne}$ ,  $^{26}\text{P}$ , and  $^{27}\text{S}$  using radioactive beams at the ACCULINNA-1 and ACCULINNA-2 setups.
- Measurement of the total reaction cross sections for the collisions of the radioactive nuclei  $^{6,8}\text{He}$ ,  $^{8,9,11}\text{Li}$ ,  $^{14}\text{Be}$ , and  $^8\text{B}$  with different targets in a wide range of energies, from the near-barrier up to 30 MeV/nucleon. Study of the mechanism of formation of new nuclei in reactions with beams of rare neutron-rich nuclei ( $^{36}\text{S}$ ,  $^{48}\text{Ca}$ ,  $^{70}\text{Zn}$ , etc.) with energies of up to 20 MeV/nucleon.
- Theoretical studies of the mechanisms of heavy-ion-induced reactions.
- Development and update of the network knowledge base on nuclear physics.
- Investigation of shapes and sizes of exotic nuclei employing laser spectroscopy methods.
- Design and construction of an ECR ion source and a hot solid-state catcher with a chemical inactive coating of the inner parts of the vacuum chambers for the MASHA separator.

**List of activities:**

<b>Activity or experiment</b>	<b>Leaders</b>	<b>Status</b>
Laboratory or other Division of JINR	<b>Main researchers</b>	
<b>1. Synthesis of new isotopes of superheavy elements at DGFRS</b>	<b>V.K. Utyonkov</b>	Data taking
FLNR	F.Sh. Abdullin, A.A. Voinov, A.M. Zubareva, A.N. Polyakov, R.N. Sagaidak, V.G. Subbotin, A.M. Sukhov, Yu.S. Tsyganov, I.V. Shirokovsky, M.V. Shumeiko, N.D. Kovrijnykh	
<b>2. <math>\alpha</math>-, <math>\beta</math>- and <math>\gamma</math>- spectroscopy of heavy nuclei at the SHELS separator</b>	<b>A.V. Yeremin</b>	Data taking
FLNR	O.N. Malyshev, A.I. Svirikhin, I.N. Izosimov, V.I. Chepigin, M.L. Chelnokov, A.V. Isaev, Yu.A. Popov, A.N. Kuznetsov, A.A. Kuznetsova, A.G. Popeko, E.A. Sokol, D.E. Katrasev, V.M. Popov, V.A. Sbitnev, I.A. Belov, M.S. Tezekbaeva	
<b>3. Chemical properties of superheavy elements</b>	<b>S.N. Dmitriev</b>	Data taking
FLNR	N.V. Aksenov, Yu.V. Albin, G.A. Bozhikov, M.G. Voronyuk, G.K. Vostokin, N.S. Gustova, I. Zvara, V.Ya. Lebedev, K.V. Lebedev, A.Sh. Madumarov, A.V. Rykhlyuk, A.V. Sabelnikov, G.Ya. Starodub	
<b>4. Experiments at the magnetic analyzer of superheavy atoms MASHA</b>	<b>A.M. Rodin</b>	Data taking
FLNR	L. Krupa, A.V. Belozerov, E.V. Chernusheva, V.Yu. Vedeneev, A.V. Guljaev, A.V. Guljaeva, D. Kamas, A.B. Komarov, S. Motychak, A.V. Podshibyakin, V.S. Salamatin, S.V. Stepantsov, A.S. Novoselov, S.A. Yukhimchuk	
<b>5. Study of the processes of fusion-fission, quasi-fission and multi-nucleon transfer reactions. CORSET-DEMON, CORSAR, and MiniFOBOS setups</b>	<b>M.G. Itkis</b>	Data taking
FLNR	E.M. Kozulin, A.A. Bogachev, Yu.M. Itkis, E.M. Gazeeva, I.N. Dyatlov, G.N. Knyazheva, N.I. Kozulina, K.V. Novikov, E.O. Savelieva, J.M. Harka, D.V. Kamanin, I.A. Alexandrova, A.A. Alexandrov, Z.I. Gorya'nova, V.E. Zhuchko, E.A. Kuznetsova, Yu.V. Pyatkov, Yu.B. Semenov, A.N. Solodov, A.O. Strekalovsky, O.V. Strekalovskiy, I.V. Vorob'ev, O.V. Falomkina, P. Steinegger, I. Chuprakov	

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|---|---|---|
| <p><b>6. Study of the structure of exotic nuclei near and beyond the drip-lines at the ACCULINNA and COMBAS fragment separators</b></p> <p>FLNR</p> <p>BLTP</p>                     | <p><b>A.S. Fomichev</b></p> <p>G.M. Ter-Akopian, M.S. Golovkov, L.V. Grigorenko, A.V. Gorshkov, V.A. Gorshkov, S.A. Krupko, A.A. Bezbakh, Yu.L. Parfenova, S.I. Sidorchuk, R.S. Slepnev, G. Kaminsky, V. Chudoba, R. Wolski, P.G. Sharov, S.A. Rimzhanova, S.G. Belogurov, Yu.M. Sereda, A.G. Artukh, A.N. Vorontsov, S.A. Klygin, G.A. Kononenko, D.A. Kislukha, N.I. Tarantin, E. Batchuluun</p> <p>S.N. Ershov, I.A. Egorova</p> | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
| <p><b>7. Investigation of reactions induced by stable and radioactive ion beams leading to the formation of exotic nuclei. Development of MAVR and MULTI setups</b></p> <p>FLNR</p> | <p><b>Yu.E. Penionzhkevich</b></p> <p>D.T. Aznabaev, M.P. Ivanov, S.M. Lukyanov, V.A. Maslov, K.O. Mendibaev, N.K. Skobelev, Yu.G. Sobolev, Z.D. Pokrovskaya, R.V. Revenko, V.I. Smirnov, D.A. Testov</p>   | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
| <p><b>8. Theoretical studies of nuclear reaction mechanisms</b></p> <p>FLNR</p>   | <p><b>A.V. Karpov</b></p> <p>A.S. Denikin, V.V. Samarin, M.A. Naumenko, E.A. Cherepanov, Yu.A. Muzichka, V.A. Rachkov, V.V. Saiko</p>   |   |
| <p><b>9. Development and update of the network knowledge base on nuclear physics</b></p> <p>FLNR</p> <p>LIT</p>   | <p><b>A.V. Karpov</b><br/><b>A.S. Denikin</b></p> <p>V.V. Samarin, V.A. Rachkov, M.A. Naumenko, V.V. Saiko</p> <p>V.V. Korenkov, P.V. Zrelov, E.I. Alexandov</p>  | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
| <p><b>10. Laser spectroscopy of isotopes</b></p> <p>FLNR</p>  | <p><b>S.G. Zemlyanoy</b></p> <p>V.I. Zhemenik, G.V. Myshinskiy, K.P. Marinova, K.A. Avvakumov</p>   | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |

### Collaboration

Country or International Organization	City	Institute or Laboratory
Belgium	Brussels	ULB
	Leuven	KU Leuven
Bulgaria	Sofia	INRNE BAS
CERN	Geneva	CERN
China	Lanzhou	IMP CAS
Czech Republic	Prague	VP
		CTU

Egypt	Řež	NPI ASCR
	Giza	CU
	Al-Minufya	MU
Finland	Jyväskylä	UJ
France	Caen	GANIL
	Orsay	CSNSM
		IPN Orsay
	Saclay	SPhN CEA
	Strasbourg	DAPNIA CRN IPHC
Germany	Berlin	HZB
	Darmstadt	GSI
	Tübingen	Univ.
	Mainz	JGU
India	Manipal	MU
	Calcutta	VECC
	New Delhi	IUAC
Italy	Catania	INFN LNS
	Legnaro	INFN LNL
	Messina	UniMe
	Naples	Unina
Japan	Wako	RIKEN
	Fukuoka	Kyushu Univ.
Kazakhstan	Almaty	INP
	Astana	ENU
Mongolia	Ulaanbaatar	NRC NUM
Poland	Warsaw	UW
	Krakow	NINP PAS
Romania	Bucharest	IFIN-HH
Russia	Moscow	IPCE RAS MSU MUCTR NNRU "MEPhI" NRC KI SINP MSU
	Moscow, Troitsk	INR RAS
	Moscow, Zelenograd	RIMST
	Cheboksary	ChSU
	Dimitrovgrad	SSC RIAR
	Gatchina	PNPI
	Sarov	VNIIEF
	St. Petersburg	KRI IPTI RAS
	Voronezh	VSU

Slovakia	Bratislava	CU IP SAS
South Africa	Stellenbosch Cape Town Pretoria	SU iThemba LABS Unisa
Spain	Huelva Madrid	UHU CSIC
Switzerland	Villigen	PSI
Sweden	Göteborg Lund	Chalmers LU
Ukraine	Kiev	KINR NASU
United Kingdom	Manchester	UoM
USA	Argonne, IL College Station, TX East Lansing, MI Livermore, CA Nashville, TN Oak Ridge, TN	ANL Texas A&M MSU LLNL VU ORNL
Vietnam	Hanoi	IOP VAST



## Non-Accelerator Neutrino Physics and Astrophysics

### Leaders:

V.B. Brudanin  
A. Kovalik  
E.A. Yakushev

### Participating Countries and International Organizations:

Armenia, Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Kazakhstan, Mongolia, Poland, Romania, Russia, Slovakia, Ukraine, USA, United Kingdom, Uzbekistan.

### Scientific Programme

Search for and investigation of double-neutrino and neutrinoless modes of double beta-decay, clarification of the neutrino nature Majorana or Dirac, absolute neutrino mass scale and hierarchies. Search for the neutrino magnetic moment and dark matter. Investigation of galactic and extragalactic neutrino sources, diffusive neutrino cosmic background, search for exotic particles (monopoles). Application of the neutrino detector for a distant investigation of process inside of the reactor core of Kalinin Nuclear Power Plant. Search for sterile neutrinos. Spectroscopy of nuclei far from stability. Development of new methods for charged and neutral particle detection.

#### Expected main results in 2017:

- Data taking in the  $2\beta 0\nu$ -decay measurements of  $^{106}\text{Cd}$ ,  $^{82}\text{Se}$ ,  $^{150}\text{Nd}$ ,  $^{76}\text{Ge}$  with the SuperNEMO and GERDA spectrometers.
- Processing of experimental data and determination of  $T_{1/2}(2\beta 2\nu)$  for  $^{48}\text{Ca}$ ,  $^{96}\text{Zr}$ ,  $^{130}\text{Te}$ ,  $^{116}\text{Cd}$ ,  $^{150}\text{Nd}$ ,  $^{82}\text{Se}$  and  $^{76}\text{Ge}$ .
- Data taking with the GEMMA-II spectrometer at the Kalinin Nuclear Power Plant; getting an upper limit for the neutrino magnetic moment at the level of  $\sim 2 \cdot 10^{-11} \mu_B$ .
- Data taking with forty FID800 detectors (cumulative fiducial mass 24 kg) in the upgraded EDELWEISS setup. Data taking with two special low energy threshold (from  $\sim 0.5$  keV) detectors in order to investigate the low mass WIMP region. The aim is to reach a WIMP-nucleon scattering cross-section sensitivity of  $5 \cdot 10^{-45} \text{cm}^2$ .
- Research and development of the semiconductor-based detecting systems for the GERDA and MAJORANA experiments. Beginning of data taking in the experiment on the search for the  $^{76}\text{Ge}$   $2\beta 0\nu$ -decay.
- Deployment and extension of the first cluster "Dubna" at Baikal-GVD array. Data taking and extraction of physical results with the detector.
- Investigation of KLL and KMM Auger electrons in  $^{65}\text{Zn}$ ,  $^{67}\text{Cu}$ ,  $^{67}\text{Ga}$  and  $^{152,154,155}\text{Eu}$  decays.
- Design and creation of the low-threshold ( $\sim 200$  eV) HPGe detector. Production of low-background plastic scintillators for the SuperNEMO experiment.
- Design and creation of the reactor antineutrino detector DANSS. Start of data taking.

### List of projects:

Project	Leader	Priority (period of realization)
1. SuperNEMO	O.I. Kochetov	1 (2013 – 2018)
2. GEMMA-II	V.B. Brudanin	1 (2010 – 2018)

3. EDELWEISS-II	E.A. Yakushev	1 (2010 – 2018)
4. G&M (GERDA)	K.N. Gusev	1 (2010 – 2018)
5. BAIKAL	I.A. Belolaptikov V.B. Brudanin	1 (2009 – 2018)
6. DANSS	V.B. Brudanin V.G. Egorov	1 (2011 – 2018)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. SuperNEMO Project	<b>O.I. Kochetov</b>	R&D Data taking
DLNP	V.A. Bednyakov, D. Filosofov, V.E. Kovalenko, V.V. Timkin, V.I. Tretyak, F. Mamedov, I. Shermak, I.I. Kamnev, O.V. Vagina, D. Karaivanov, Yu. Shitov	
BLTP	F. Simkovic	
2. TGV Project	<b>N.I. Rukhadze</b> <b>I. Shtekl</b>	Data taking
DLNP	V.G. Sandukovsky, F. Mamedov, I. Shermak, S.L. Katulina	
BLTP	F. Simkovic	
3. G&M (GERDA-MAJORANA Project)	<b>K.N. Gusev</b>	Preparation Data taking
DLNP	V.G. Sandukovsky, V.B. Brudanin, A.A. Klimenko, A.V. Lubashevsky, D.R. Zinatulina, S.L. Katulina, N.S. Rumyantseva, E.A. Shevchik, I.V. Zhitnikov, I. Shermak	
BLTP	F. Simkovic	
4. GEMMA-II Project	<b>V.B. Brudanin</b> <b>V.G. Egorov</b>	Modernization Data taking
DLNP	D.V. Medvedev, N.S. Rumyantseva, M.V. Fomina, M.V. Shirchenko, A.S. Kuznetsov, D.V. Ponomarev, E.A. Yakushev	
5. EDELWEISS-II Project	<b>E.A. Yakushev</b>	Data taking
DLNP	V.A. Bednyakov, S.V. Rozov, S.V. Fateev, L.L. Perevoshchikov, D.V. Filosofov, A.V. Lubashevsky	
6. BAIKAL Project	<b>I.A. Belolaptikov</b> <b>V.B. Brudanin</b>	Preparation Data taking
DLNP	V.G. Egorov, K.V. Konishev, V.P. Lomov, M.B. Milenin, A.V. Korobchenko, A.A. Perevalov, E.N. Pliskovski, A.I. Panfilov, B.A. Shaibonov, F.A. Shamakhov, M.V. Shirchenko, A.A. Klimenko, Z. Hons, I.E. Rozova, A.V. Salamatin, A.A. Smagina	

## 7. DANSS Project

**V.B. Brudanin**

**V.G. Egorov**

Preparation
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DLNP

D.R. Zinatulina, E.A. Shevchik, I.V. Zhitnikov,  
N.S. Rummyantseva, M.V Fomina, V. Belov, A.S. Kuznetsov,  
I.E. Rozova, M.V. Shirchenko

### Collaboration

**Country or International  
Organization**

**City**

**Institute or Laboratory**

Armenia	Yerevan	YSU Foundation ANSL
Belgium	Leuven	KU Leuven
Bulgaria	Sofia	INRNE BAS
	Plovdiv	PU
Czech Republic	Prague	CTU
	Řež	NPI ASCR
Finland	Jyväskylä	UJ
France	Orsay	CSNSM LAL
	Bordeaux	CENBG
	Caen	UNICAEN
Germany	Heidelberg	MPIK
	Mainz	JGU
Kazakhstan	Almaty	INP
Mongolia	Ulaanbaatar	NRC NUM NEC
Poland	Krakow	NINP PAS AGH-UST
	Lublin	UMCS
	Otwock-Swierk	NCBJ
Romania	Bucharest	IFIN - HH UB
Russia	Moscow, Troitsk	INR RAS
	Gatchina	PNPI
	Voronezh	VSU
	Moscow	NRC KI SC "VNIINM" NNRU "MEPhI" ITEP SINP MSU INTRA RADON
	Sarov	VNIIEF
	St. Petersburg	SPbSU IPTI RAS

	Tomsk	NPI TPU IHCE SB RAS
Slovakia	Bratislava	CU IEE SAS
Ukraine	Kiev	KINR NASU
	Kharkov	ISC NASU
USA	Irvine, CA	UCI
	Austin, TX	UT
United Kingdom	London	UCL
	Manchester	UoM
Uzbekistan	Tashkent	INP AS RU <sub>z</sub> IAP NUU
	Samarkand	SSU

03-2-1101-2010/2017

Priority:

1

Status:

Extended

## Physics of Light Mesons

**Leader:**

A.V. Kulikov

**Deputy:**

Z. Tsamalaidze

### Participating Countries and International Organizations:

Belarus, Bulgaria, Croatia, Canada, Czech Republic, Georgia, Germany, Italy, Poland, Romania, Russia, Switzerland, USA, Japan.

### Scientific Programme

Investigation of strong, weak and electromagnetic interactions of elementary particles and light nuclei at intermediate energies with the aim of determining symmetries and dynamics of the interactions. Development and construction of setups for experiments at accelerators for obtaining new information and testing the present theoretical views in the topics. Development of projects for new experiments and experimental methods for intermediate-energy physics.

#### Expected main results in 2017:

- Processing of the experimental data for decays  $\mu^+ \rightarrow e^+ \gamma$  and  $\pi \rightarrow e \nu$ .
- Measurements of spin observables at longitudinally and transversely polarized COSY beam. Development of the polarimeter for the experiment on search for electric dipole moment.
- Data taking and data processing for  $p + t$  fusion reaction using the muon catalysis method.
- Determination of branching ratios for reaction channels of pion interactions with the helium nucleus at the JINR Phasotron.
- Study of the dynamic behavior of magnetic nanoparticles at the cobalt ferrites by the muon spin rotation technique. Hyperfine interaction of acceptor center in semiconductors.
- Experiments with the "Active Target" (GDH).
- Measurement of  $A_N$  for the inclusive and exclusive reactions  $\pi^- p \rightarrow \omega (782)n$  and  $\pi^- p \rightarrow \eta' (958)n$ .
- R&D on thin-wall straw-tubes for experiment COMET. Development, production and tests of the straw detector and electromagnetic calorimeter prototypes with a beam.

### List of projects:

Project	Leader	Priority (period of realization)
1. GDH&SPASCHARM	Yu. Usov A. Kovalik	1 (2011 – 2019)

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. GDH&SPASCHARM Project	Yu. Usov A. Kovalik	Data taking Data processing

DLNP	N.S. Borisov, N.A. Bazhanov, A.N. Fedorov, Yu.A. Plis, A.B. Lazarev, A.B. Neganov, A.B. Sadovsky, I.V. Gapienko, I.S. Gorodnov	
BLTP	S.B. Gerasimov, S.S. Kamalov	
<b>2. Experiment SPRING</b>	<b>A.V. Kulikov</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Data analysis</td></tr></table>	Data analysis
Data analysis		
DLNP	V.I. Komarov, Yu.N. Uzikov, A.D. Volkov, Zh. Kurmanaliev, S.N. Dymov, V.V. Shmakova, T.I. Azaryan, V.S. Kurbatov, D.A. Tsirkov, B. Baimurzinova, A. Kunsafina	
<b>3. Experiment COMET</b>	<b>Z. Tsamalaidze</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>R&amp;D Realization</td></tr></table>	R&D Realization
R&D Realization		
DLNP	P.G. Evtukhovich, A.S. Moiseenko, V.G. Kalinnikov, E.P. Velicheva, A.D. Volkov, B.M. Sabirov, N. Tsverava, I.L. Evtukhovich, Kh. Khubashvili, E.M. Kulish, A.G. Samartsev, V.N. Duginov, K.I. Gritsai, Yu.Yu. Stepanenko	
LIT	A. Khvedelidze, G. Adamov	
BLTP	G.A. Kozlov	
VBLHEP	S.A. Movchan, S.N. Shkarovsky, V.V. Elsha, T.L. Enik	
<b>4. Experiment MEG-PEN</b>	<b>N.A. Kuchinskiy</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Data processing</td></tr></table>	Data processing
Data processing		
DLNP	V.A. Baranov, V.A. Kalinnikov, N.V. Khomutov, S.M. Korenchenko, N.P. Kravchuk, E.S. Kuzmin, A.S. Moiseenko, A.M. Rozhdestvensky, Z. Tsamalaidze, E.P. Velicheva, V.P. Volnykh, A.S. Khrykin	
BLTP	Yu.M. Bystritsky	
<b>5. Experiment PAINUC</b>	<b>N.A. Russakovich</b> <b>G. Piragino</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Data taking Data analysis</td></tr></table>	Data taking Data analysis
Data taking Data analysis		
DLNP	G.B. Pontecorvo, N.S. Angelov, I.A. Belolaptikov, T.D. Blokhintseva, V.N. Frolov, V.M. Grebenyuk, V.E. Kovalenko, A.S. Moiseenko, A.M. Rozhdestvensky, S.A. Gustov	
LIT	V.V. Ivanov	
LRB	V.A. Panyushkin	
VBLHEP	P.N. Batyuk	
<b>6. Experiment MUON</b>	<b>V.N. Duginov</b> <b>T.N. Mamedov</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Data taking Data analysis</td></tr></table>	Data taking Data analysis
Data taking Data analysis		
DLNP	E.I. Bunyatova, K.I. Gritsaj, A.I. Rudenko, G.D. Soboleva	
FLNP	M. Balasoii	
<b>7. Experiment TRITON</b>	<b>D.L. Demin</b> <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>Data analysis</td></tr></table>	Data analysis
Data analysis		

DLNP	A.M. Artikov, N.S. Azaryan, N.A. Baranova, A.I. Boguslavsky, V.P. Volnykh, K.I. Gritsaj, V.N. Duginov, V.I. Kolomoets, A.D. Konin, A.P. Kustov, N.N. Kashirina, T.N. Mamedov, A.I. Rudenko, A.V. Simonenko, Yu.A. Polyakov, S.A. Gustov, N.A. Shakun, E.V. Kolesov, V.I. Smirnov, E.D. Gorodnichev
FLNR	S.A. Yukhimchuk
LRB	V.B. Buchnev, V.Yu. Schegolev

## Collaboration

Country or International Organization	City	Institute or Laboratory	
Belarus	Minsk	IP NASB	
		BSU	
		INP BSU	
Bulgaria	Sofia	SU	
Czech Republic	Prague	CU	
	Řež	NPI ASCR	
France	Saclay	IRFU	
Croatia	Zagreb	RBI	
Canada	Vancouver	TRIUMF	
Georgia	Tbilisi	HEPI-TSU	
Germany	Aachen	RWTH	
	Heidelberg	Univ.	
	Jülich	FZJ	
	Cologne	Univ.	
	Dresden	HZDR	
	Mainz	JGU	
	Münster	Univ.	
	Stuttgart	MPI-MF	
	Italy	Frascati	INFN LNF
		Ferrara	UniFe
		Rome	Univ. "La Sapienza"
Japan	Turin	INFN	
	Kyoto	Kyoto Univ.	
	Osaka	Osaka Univ.	
	Tsukuba	KEK	
Poland	Krakow	NINP PAS	
	Otwock-Swierk	NCBJ	
Romania	Bucharest	IFIN - HH	
	Timișoara	CCTFA	
	Alexandrov	VNIISIMS	
Russia	Gatchina	PNPI	
	Dolgoprudny	MIPT	
	Moscow	ITEP	

		GPI RAS
		SINP MSU
		NRC KI
		INR RAS
		VNIIEF
		UZH
		PSI
		UVa
		Pitt
		UA
	Moscow, Troitsk	
	Sarov	
Switzerland	Zurich	
	Villigen	
USA	Charlottesville, VA	
	Pittsburgh, PA	
	Tucson, AZ	



## Improvement of the JINR Phasotron and Design of Cyclotrons for Fundamental and Applied Research

**Leaders:** G.A. Karamysheva

S.L. Yakovenko

**Scientific leader:** L.M. Onischenko

### Participating Countries and International Organizations:

Belgium, China, Poland, Japan, USA, Uzbekistan.

### Scientific Programme

Improvement of the JINR Phasotron and beam channels. Design of the cyclotrons for medical purposes. Development of the cyclotron method for high-current beam acceleration.

#### Expected main results in 2017:

- Modernization of the automated beam channel control system of JINR Phasotron.
- Carrying out simulation and experimental works on AIC-144 cyclotron increase of the beam extraction factor. Participation in the development of the magnets for the beam transport line to the cabin of the eye melanoma therapy.
- Development of the project superconducting cyclotron for SC200 proton therapy.
- Axial injection design and construction stage simulations for ProNova K230 superconducting cyclotron for proton therapy.

### List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Improvement of the JINR Phasotron and beam channels  DLNP	S.L. Yakovenko N.G. Shakun L.M. Onischenko  A.S. Vorozhtsov, S.B. Vorozhtsov, S.A. Gustov, G.A. Kononenko, N.A. Morozov, I.V. Mirokhin, Yu.A. Polyakov, V.I. Smirnov, E.V. Samsonov, V.M. Romanov, V.A. Utkin	Realization
2. Design and modernization of the cyclotrons for medical purpose  DLNP	G.A. Karamysheva N.A. Morozov  A.S. Vorozhtsov, S.V. Gursky, S.B. Vorozhtsov, S.N. Dolya, O.V. Karamyshev, R.V. Galkin, D.S. Petrov, O.E. Lepkina, O.V. Lomakina, S.G. Shirkov, N.L. Zaplatin, G.G. Kazakova, I.N. Kiyana, V.M. Romanov, E.V. Samsonov, V.G. Sazonov, A.F. Chesnov, I.M. Sedyh	Technical proposal
LIT	I.V. Amirkhanov	

**3. Research and development of the superconducting cyclotron for proton therapy for IPP CAS, Hefei, China**

**G.D. Shirkov**

R&D
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DLNP

R.V. Galkin, S.V. Gursky, O.V. Karamyshev, I.N. Kiyan, O.E. Lepkina, O.V. Lomakina, N.A. Morozov, V.M. Romanov, E.V. Samsonov, A.F. Chesnov, D.V. Popov, S.G. Shirkov

VBLHEP

A.S. Kostromin

LIT

I.V. Amirhanov, T.V. Karamysheva

**4. Development of the cyclotron method for high-current beam acceleration**

**L.M. Onischenko  
S.B. Vorozhtsov**

Technical proposal
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DLNP

A.S. Vorozhtsov, N.L. Zaplatin, E.V. Samsonov, V.L. Smirnov, V.M. Romanov, E.A. Saprykin

**Collaboration**

**Country or International Organization**

**City**

**Institute or Laboratory**

Belgium

Louvain-la-Neuve

IBA

Japan

Chiba

NIRS

China

Hefei

IPP CAS

Japan

Chiba

NIRS

Poland

Krakow

NINP PAS

USA

Lansing, MI

IONETIX

Uzbekistan

Tashkent

INP AS RUz

## Investigations of Neutron Nuclear Interactions and Properties of the Neutron

**Leader:** V.N. Shvetsov  
**Deputies:** Yu.N. Kopatch  
 E.V. Lychagin  
 P.V. Sedyshev

### Participating Countries and International Organizations:

Albania, Australia, Austria, Azerbaijan, Belarus, Belgium, Bulgaria, CERN, China, Croatia, Czech Republic, Egypt, Finland, France, Georgia, Germany, Hungary, India, Italy, Japan, Kazakhstan, Macedonia, Moldova, Mongolia, Norway, Poland, Republic of Korea, Romania, Russia, Serbia, Slovakia, Slovenia, South Africa, Switzerland, Thailand, Turkey, Ukraine, USA, Vietnam.

### Scientific Programme

Experimental and theoretical investigation of symmetry breaking effects in reactions with neutrons and fundamental properties of the neutron to test the parameters of the Standard Model and search for “new physics”. Investigation of the properties of excited nuclei, reactions with emission of charged particles, fission physics. Obtaining of relevant data for astrophysics, nuclear power engineering and nuclear waste transmutation problem using neutron- and gamma-induced reactions. Application of neutron physics methods in other fields of science and technology. Development and construction of detectors of neutrons and other ionizing radiation, as well as applied methods in nuclear physics with neutrons. Development of the Intense REsonance Neutron Source (IREN) and the experimental base at the IREN and IBR-2 facilities.

#### Expected main results in 2017:

##### Investigations of violations of fundamental symmetries in neutron-nucleus interactions and related data

- Determination of parameters of the ROT-effect in the fission of  $^{235}\text{U}$  by neutrons with an energy of 0.3 eV.
- Treatment of the results from the measurements of P-odd effect in the reaction of  $^{10}\text{B}(n,\alpha)^7\text{Li}$  performed in 2016 at ILL, Grenoble.
- Development of the design of an instrument for measuring the P-odd effect in the reaction of  $^3\text{He}(n,p)^3\text{H}$ .
- Investigation of neutron paramagnetic resonance of the first kind in samples of titanium hydride  $\text{TiH}_2$  in the polarized neutron energy range of 0.062-2.3 eV using the KOLKHIDA facility at the IBR-2 reactor.
- Investigation of prompt fission neutrons and superfluidity properties of fission fragments (IREN). Investigation of the dynamics of interaction of Fermi- and Bose-states of nuclear matter on the basis of experimental data on the intensities of two-quantum cascades of radiative neutron capture in various excited nuclei including actinides and fission products. The corresponding analysis of data from the experiment with a  $^{93}\text{Nb}$  target performed in Budapest by employees of the University of Novi Sad, Belgrade.
- Measurement and analysis of angular correlations in the emission of neutrons and light charged particles in the spontaneous fission of  $^{252}\text{Cf}$ .
- Measurement of angular correlations in the emission of neutrons and gamma-rays in inelastic neutron scattering for various elements in the framework of the TANGRA project.
- Development of an alpha spectrometer on beamline №1 of IREN; test measurements of the  $^6\text{Li}(n,\alpha)^3\text{H}$  reaction.

- Measurements of the  $(n,\alpha)$  reaction with Ni-58,60,61 isotopes for neutron energies  $E_n = 4.5-6.5$  MeV at the accelerators EG-5 in FLNP JINR and EG-4.5 of the Institute of Heavy Ion Physics of Peking University.
- Treatment of experimental data from the measurements of the  $^{25}\text{Mg}(n,\alpha)^{22}\text{Ne}$  and  $^{91}\text{Zr}(n,\alpha)^{88}\text{Sr}$  reactions induced by fast neutrons.

#### **Investigation of fundamental properties of the neutron, UCN physics:**

- Experimental determination of characteristics of resonance transitions between quantum states of neutrons in the gravitational field of the Earth using the GRANIT spectrometer.
- Determination of the possibility of practical application of diamond nanopowder reflectors for targeted extraction of very cold neutrons.
- Development of the design of a setup to measure the energy dependence of the UCN loss factor in the energy range close to limiting values.
- Design and manufacture of a new time-of-flight Fourier diffractometer for neutron free fall experiments.
- Preparation of the experiment for observation of neutron quantum tunneling through an oscillating potential structure: quantum calculations, development and testing of the experimental setup.
- Nonstationary quantum experiments with slow neutrons: neutron diffraction by surface ultrasonic waves and reflection from an oscillating mirror.

#### **Applied and methodological research:**

- Development of gas-filled position-sensitive detectors of charged particles to conduct investigations of nuclear fission, in neutron radiography and in condensed matter physics.
- Inspection of the technical condition of the charged particle accelerator EG-5 in the framework of preparation to the development of a microbeam.
- Investigation of depth profiles of elements in the near-surface layers of solids using nuclear-physics methods (Elastic Recoil Detection Analysis and Rutherford Backscattering Spectrometry).
- Elemental and isotopic analysis of samples at the IREN facility using neutron spectroscopy, neutron and gamma activation analyses.
- Development of the elemental analysis of geological specimens and ores using the tagged neutron method as well as standard neutron sources.
- Carrying out of neutron activation analysis of environmental, geological, biological samples and novel materials at the IBR-2 reactor using the REGATA facility in the framework of the projects supported by grants and programs of Member States and Associated Members of JINR, RFBR and IAEA.
- Upgrade of hot cells of the REGATA facility to work with highly active samples.
- Improvement of the database for carrying out NAA using three automatic sample changers to measure the induced radioactivity generated by irradiation in the IBR-2 beamlines.
- Construction of a spectrometric system to measure natural and man-made radioactivity for radioecological and materials science research.

#### **Development of the IREN facility**

- Operation of the accelerator comprising two accelerating sections with a beam at a frequency of 50 Hz. Providing the neutron beam time of 1000 hours from IREN for physical experiments.
- Modernization of experimental beamline N1 of the IREN facility.

**List of projects:**

<b>Project</b>	<b>Leader</b>	<b>Priority (period of realization)</b>
1. TANGRA	Yu.N. Kopatch Deputy: V.M. Bystritsky (DLNP)	1 (2014 – 2019)

**List of activities:**

<b>Activity or experiment Laboratory or other Division of JINR</b>	<b>Leaders Main researchers</b>	<b>Status</b>
1. <b>Investigations of violations of fundamental symmetries in neutron-nucleus interactions and related data</b>  FLNP	<b>Yu.N. Kopatch</b>  G.S. Ahmedov, N.V. Bazjazjina, S.B. Borzakov, D. Berikov, Vu Dyk Kong, G.V. Daniljan, Yu.M. Gledenov, D.N. Grozdanov, N.A. Gundorin, Sh.S. Zeynalov, A.P. Kobzev, M. Kulik, D. Mahajdik, Zh.V. Mezentseva, V.V. Novitsky, I.A. Oprea, K.D. Oprea, Yu.N. Pokotilovskij, I.N. Ruskov, P.V. Sedyshev, M.V. Sedysheva, O.V. Sidorova, V.R. Skoj, A.M. Suhovoj, S.A. Telezhnikov, V.A. Hitrov, M. Tsulaja, Ho Hyu Ehang, Chan Van Fuk, Czan Tzjanfu + 16 engineers, + 2 workers	Upgrade Data taking Data analysis
2. <b>Investigation of the fundamental properties of the neutron, UCN physics</b>  FLNP	<b>E.V. Lychagin</b>  G.G. Bunatyan, S.V. Gorunov, V.K. Ignatovich, G.V. Kulin, L.V. Mitsyna, A.Yu. Muzychka, Yu.N. Pokotilovskij, A.B. Popov, A.V. Strelkov, A.I. Frank, W.I. Furman, E.I. Sharapov, T.L. Enik + 1 engineer	Upgrade Data taking Data analysis
3. <b>Applied research</b>  FLNP	<b>P.V. Sedyshev</b>  M.V. Frontasyeva, S.S. Pavlov, Yu.V. Alekseenok, A.S. Vasilev, K.N. Vergel, A.Yu. Dmitriev, I.I. Zinikovskaja, O.A. Culikov, A.Madadzade, P.S. Nekhoroshkov, A.V. Kravtsova, Doan Fan Thao Tien, G.Y. Khristozova, G.S. Ahmedov, N.V. Bazjazjina, S.B. Borzakov, Vu Dyk Kong, Vu Dyk Fu, Yu.M. Gledenov, N.A. Gundorin, Sh.S. Zeynalov, A.P. Kobzev, Yu.N. Kopatch, M. Kulik, D. Mahajdik, Zh.V. Mezentseva, V.V. Novitsky, I.A. Oprea, K.D. Oprea, T.M. Ostrovnaya, I.N. Ruskov, B.D. Rumyantsev, M.V. Sedysheva, V.R. Skoj, A.M. Suhovoj, S.A. Telezhnikov, W.I.Furman, M. Tsulaja, G.V. Daniljan, Chan Van Fuk + 24 engineers, + 5 workers	Upgrade Data taking Data analysis

**4. Development of the IREN facility**      **V.N. Shvetsov**      Upgrade

FLNP      V.G. Pjataev, + 13 engineers + 1 worker

VBLHEP      V.V. Kobets, V.F. Minashkin, V.G. Shabratov,  
A.P. Sumbaev      V.N. Zamrij, A.N. Skrypnik, J. Betscher

DLNP      I.N. Meshkov

**5. Project TANGRA**      **Yu.N. Kopatch**      Upgrade  
Data taking  
Data analysis

FLNP      F. Aliev, S.B. Borzakov, D. Grozdanov, N.A. Gundorin,  
P.A. Dubasov, Sh.S. Zeinalov, A.O. Zontikov, I.A. Oprea,  
K.D. Oprea, A.V. Rogachev, P.V. Sedyshev, V.R. Skoi,  
V.N. Shvetsov

VBLHEP      U.Yu. Aleksakhin, U.I. Zamjatin, E.U. Zubarev,  
U.L. Rapackii, Yu.N. Rogov, R.A. Salmin,  
M.G. Sapozhnikov, U.V. Slepnev, S.U. Khabarov

DLNP      U.M. Bystritskii, A.U. Krasnoperov, A.U. Sadovskii,  
A.U. Salamatin

LRB      A.R. Krylov, G.N. Timoshenko

**Collaboration**

<b>Country or International Organization</b>	<b>City</b>	<b>Institute or Laboratory</b>
Albania	Tirana	UT
Armenia	Yerevan	CENS NAS RA
Australia	Melbourne	Univ.
Austria	Vienna	IAEA
	Innsbruck	Univ.
Azerbaijan	Baku	BSU
	Ganja	ASAU
		ATU
Belarus	Minsk	INP BSU
Belgium	Geel	IRMM
Bulgaria	Sofia	INRNE BAS
	Plovdiv	PU
		UFT
CERN	Geneva	CERN
China	Beijing	IHEP CAS
Croatia	Zagreb	RBI
		Oikon IAE
Czech Republic	Prague	CEI
		CTU
	Ostrava	VSB-TUO
Egypt	Alexandria	Univ.
	Cairo	EAEA

Finland	Shibin al Kawm	MU	
	Jyväskylä	UJ	
	Oulu	UO	
France	Cadarache	CC CEA	
	Grenoble	ILL	
		LPSC	
	Saclay	LLB	
	Strasbourg	IPHC	
Georgia	Tbilisi	AIP TSU	
		TSU	
Germany	Darmstadt	TU Darmstadt	
	Dresden	HZDR	
	Mainz	JGU	
	Munich	TUM	
	Tübingen	Univ.	
		RKK OU	
Hungary	Budapest		
India	Varanasi	BHU	
Italy	Rome	ENEA	
Japan	Kyoto	KSU	
	Tsukuba	KEK	
		INP	
Kazakhstan	Almaty	ENU	
	Astana	TRCE	
	Ust-Kamenogorsk	UKiM	
		IMB ASM	
Macedonia	Skopje		
Moldova	Chişinău		
Mongolia	Ulaanbaatar	CGL	
		NUM	
Norway	Trondheim	NTNU	
Poland	Gdansk	GUT	
	Krakow	NINP PAS	
	Lodz	UL	
	Lublin	UMCS	
	Opole	UO	
	Otwock-Swierk	NCBJ	
	Poznan	AMU	
	Wroclaw	UW	
	Republic of Korea	Pohang	PAL
		Seoul	Dawonsys
		Daejeon	KAERI
	Romania	Bucharest	IFIN-HH
			INCDIE ICPE-CA
		ISS	
		UB	
	Baia Mare	TUCN-NUCBM	
	Constanța	NIMRD	

		UOC
		UG
		UAIC
		UO
		SCN
		I.C.S.I.
		UVT
Russia	Galați	Atomenergomach
	Iași	GIN RAS
	Oradea	IKI RAS
	Pitești	IPCE RAS
	Râmnicu Vâlcea	ITEP
	Târgoviște	MSU
	Moscow	NRC KI
		SINP MSU
		GPI RAS
		VNIIA
	Moscow, Troitsk	INR RAS
	Borok	IBIW RAS
	Dubna	Diamant
		Dubna Univ.
	Gatchina	PNPI
	Irkutsk	LI SB RAS
	Ivanovo	ISUCT
	Izhevsk	UdSU
	Obninsk	IPPE
	Snezhinsk	VNIITF
	St. Petersburg	Botanic Garden
		BIN RAS
		FIP
		SPSFTU
		Hermitage
		KRI
		IBSS
	Sevastopol	TSPU
	Tula	VSU
	Voronezh	UrFU
Serbia	Yekaterinburg	IPB
	Belgrade	Univ.
		UNS
Slovakia	Novi Sad	IP SAS
	Bratislava	IEE SAS
		ILE SAS
		CU
Slovenia	Ljubljana	GeoSS



South Africa	Pretoria	Unisa
	Stellenbosch	SU
	Pretoria	Unisa
Switzerland	Villigen	PSI
Thailand	Hat Yai	PSU
Turkey	Çanakkale	ÇOMU
Ukraine	Kiev	KINR NASU
		NUK
	Donetsk	DonIPE
	Sumy	IAP NASU
	Uzhgorod	IEP NASU
	Kharkov	ISMA NASU
		KFTI
Vietnam	Hanoi	IOP VAST
		VNU
USA	Durham, NC	Duke
	Gettysburg, PA	GC
	Kingston, RI	URI
	Los Alamos, NM	LANL
	Oak Ridge, TN	ORNL



Condensed  
Matter Physics,  
Radiation  
and Radiobiological  
Research  
(04)

## Investigations of Condensed Matter by Modern Neutron Scattering Methods

### Leaders:

D.P. Kozlenko  
V.L. Aksenov  
A.M. Balagurov

### Participating Countries and International Organizations:

Argentina, Azerbaijan, Belarus, Bulgaria, Czech Republic, Egypt, France, Germany, Hungary, India, Italy, Japan, Kazakhstan, Latvia, Moldova, Mongolia, Norway, Poland, Romania, Russia, Serbia, Slovakia, Spain, South Africa, Switzerland, Taiwan, Tajikistan, Ukraine, United Kingdom, Uzbekistan, Vietnam.

### Scientific Programme

Investigations of structure, dynamics and microscopic properties of novel materials and nanosystems, interesting for fundamental research in the fields of condensed matter physics, chemistry, materials science, geophysics, and important for the development of nanotechnologies in the field of electronics, pharmacology, medicine by neutron scattering and complimentary methods.

#### Expected main results in 2017:

##### Realization of the scientific program:

- Determination of parameters of atomic and magnetic structure of bulk and nanostructured functional materials demonstrating interesting physical phenomena and being promising for technological applications in a wide range of thermodynamic parameters; exploration of the role of cluster aggregation in the formation of physical properties.
- Determination of characteristics of atomic and magnetic structure of nanosized complex manganese oxides.
- Analysis of the relationship between changes of atomic and magnetic structure parameters of improper multiferroics under variation of thermodynamic parameters (pressure, temperature).
- Revealing of structural modifications of electrodes of compact electric current sources during charging/discharging processes.
- Determination of magnetic properties and elucidation of nanoscale phenomena in magnetic layered nanostructures in constant and variable magnetic fields.
- Comparative analysis of structural aspects of stabilization of disperse systems and complex liquids with nonmagnetic and magnetic nanoparticles in bulk and interface boundaries.
- Determination of structural characteristics of nanosystems based on compositional C- and Si-containing materials.
- Determination of structural characteristics of magnetic elastomers and carbosilane dendrimers holding promise for technological applications.
- Determination of atomic structure and vibrational spectra of molecular complexes: ionic-molecular inclusive materials and complexes with electric charge transfer, structural and dynamical parameters of hydrogen bonding in bioactive materials.
- Determination of structural and functional characteristics of biological nanosystems.

- Determination of structural characteristics of lipid nanosystems modeling upper skin layer of human and mammal animals in order to study the transport of pharmacological drugs through the skin.
- Determination of regularities of occurrence of instability of rocks under high temperatures and pressures, in particular, during polymorphic phase transition for the development of models of the processes in the earthquake focus.
- Analysis of metamorphic, geodynamic and evolution processes in the lithosphere using the data about the texture of deep and near-surface earth rocks. Exploration of seismic anisotropy origin.
- Development of solid polycrystalline material models for prediction of their elastic, strength and thermal properties taking into account texture, inclusions, pores and microcracks.
- Determination of residual stresses in engineering materials of nuclear reactors, industrial materials and products – composites, reinforced systems, metal ceramics, shape memory alloys.
- Elaboration of radiation damage mechanisms of solid-state materials, obtaining of long-life operating data on radiation resistance of materials.

**Realization of the instrument development program for the IBR-2 spectrometers:**

- Creation of the final configuration of the DN-6 diffractometer and relevant infrastructure (detector system, mechanical units, set of high-pressure cells, infrastructure for loading pressure cells).
- Creation of the final configuration of the multifunctional reflectometer GRAINS (polarizing system, mechanical part and sample unit).
- Modernization of the available IBR-2 spectrometers (HRFD, YuMO, FSD, REFLEX, REMUR, NERA, SKAT, EPSILON, DIN-2PI) aimed at improving their instrumental parameters (neutron counting rate, background conditions, and extension of experimental opportunities).
- Completion of the reconstruction of the high-intensity DN-2 diffractometer into a real-time diffractometer (RTD).
- Creation of the test configuration of the small-angle spin-echo spectrometer on IBR-2 beamline 9.
- Creation of the basic configuration of the neutron radiography and tomography spectrometer on IBR-2 beamline 14.
- Adaptation of the correlation spectrometer FSS (transported from HZG, Germany, via PNPI) to methodological and research activities on IBR-2 beamline 13.
- Development and testing of neutron scattering methods for condensed matter research including spin-echo, neutron standing waves, neutron magnetic resonance, radiography, tomography, etc.

**List of projects:**

<b>Project</b>	<b>Leader</b>	<b>Priority (period of realization)</b>
1. IINR	Yu.V. Nikitenko Deputy: N.A. Gundorin	1 (2015 – 2018)

**List of activities:**

Activity or experiment	Leaders	Status
Laboratory or other Division of JINR	Main researchers	
1. Study of structure and properties of novel functional materials  FLNP	A.M. Balagurov D.P. Kozlenko  B. Argymbek, A.I. Beskrovnyi, B.N. Savenko, E.B. Askerov, I.A. Bobrikov, E.V. Ermakova, N.O. Golosova, S.E. Kichanov, M.L. Craus, E.V. Lukin, G.M. Mironova, D.T. Neov, A. Pawlukojs, A.V. Rutkauskas, N.Yu. Samoylova, S.G. Sheverev, V.A. Turchenko, U. Enhnaran, M.T. Vu	Data taking
2. Study of structure and properties of materials under extreme conditions  FLNP	D.P. Kozlenko  S.E. Kichanov, B.N. Savenko, E.V. Lukin, A.V. Rutkauskas, M.T. Vu, N.M. Belozerova	Data taking
3. Study of fundamental regularities of real time processes in condensed matter  FLNP	A.M. Balagurov  A.I. Beskrovnyi, I.A. Bobrikov, O.Yu. Ivanshina, G.M. Mironova, D. Neov, N.Yu. Samoylova, V.G. Simkin, U. Einhnaran	Data taking
4. Computer modeling of physical and chemical properties of novel crystalline and nanostructured materials  FLNP	A. Pawlukojs  K.S. Druzicki, K.M. Luczynska, J.M. Nowicka-Scheibe, D.M. Chudoba	Data taking
5. Study of magnetic properties of layered nanostructures  FLNP	Yu.V. Nikitenko  S.V. Kozhevnikov, V.D. Zhaketov	Data taking
6. Study of structural characteristics of carbon- and silicon-based nanomaterials  FLNP	V.L. Aksenov  T.V. Tropin, O.A. Kizima, D.M. Chudoba, T. Nagornaya, A.A. Tomchuk, Zh. Narmandah	Data taking
7. Investigation of structure and molecular dynamics of biologically active materials and molecular ionic crystals  FLNP	D.M. Chudoba  P. Bilski, K.S. Druzicki, E.A. Goremychkin, K.M. Luczynska, A. Filarowski, T. Nagornaya, J. Waliszewski	Data taking

- |   |   |   |
|---|---|---|
| <p>8. <b>Study of dispersed systems and complex liquids in bulk and at interface boundaries</b></p> <p>FLNP</p>                   | <p><b>M.V. Avdeev</b></p>   | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
|   | <p>V.I. Petrenko, K.T. Kholmurodov, A.V. Nagornyi, A.V. Tomchuk, I.V. Gapon, A.P. Artikulny, M.O. Kuzmenko</p>  |   |
| <p>9. <b>Structural characterization of polymer nanodispersed materials</b></p> <p>FLNP</p>                                       | <p><b>M. Balasoiu</b></p>   | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
|   | <p>A.I. Kuklin, A.Kh. Islamov, O. Ivan'kov, D.V. Solovyev, A.V. Rogachev</p>  |   |
| <p>10. <b>Study of supramolecular structure and functional characteristics of biological materials</b></p> <p>FLNP</p> <p>LIT</p> | <p><b>A.I. Kuklin</b></p>   | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
|   | <p>A.Kh. Islamov, T.N. Murugova, M. Balasoiu, Yu.E. Gorshkova, O. Ivan'kov, R.V. Erhan, D.V. Solovyev, Yu.S. Kovalev, A.V. Rogachev, A.A. Nabiev, S.F. Samadov</p> <p>D.V. Solovyev, T.V. Solovyeva</p> |   |
| <p>11. <b>Study of structure and properties of lipid membranes and lipid complexes</b></p> <p>LIT</p>                             | <p><b>M.A. Kiselev</b></p>  | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
|   | <p>E.V. Zemlyanaya, E.I. Zhabitskaya</p>  |   |
| <p>12. <b>Study of texture and physical properties of Earth's rocks, minerals and engineering materials</b></p> <p>FLNP</p>       | <p><b>Ch. Scheffzuek</b><br/><b>D.I. Nikolaev</b></p>   | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
|   | <p>R.N. Vasin, T.I. Ivankina, V.V. Sikolenko, T.A. Lychagina, I.Yu. Zel', B. Altangerel</p>   |   |
| <p>13. <b>Non-destructive control of residual stresses in industrial products and engineering materials</b></p> <p>FLNP</p>       | <p><b>G.D. Bokuchava</b></p>  | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
|   | <p>V.V. Sumin, R.N. Vasin, I.V. Papushkin, A.A. Kruglov, A.V. Tamonov, B. Muhametuly, Yu.V. Taran, D.M. Levin</p>   |   |
| <p>14. <b>Neutron imaging of internal structure of industrial products, rocks and natural heritage objects</b></p> <p>FLNP</p>    | <p><b>D.P. Kozlenko</b><br/><b>G.D. Bokuchava</b></p>   | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
|   | <p>B.N. Savenko, S.E. Kichanov, E.V. Lukin, A.V. Rutkauskas</p>   |   |
| <p>15. <b>Study of radiation damage effects in condensed matter by X-ray spectroscopy</b></p> <p>VBLHEP</p>                       | <p><b>S.I. Tyutyunnikov (VBLHEP)</b></p>  | <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">Data taking</div> |
|   | <p>V.N. Shalyapin, V.V. Efimov, E.A. Efimova, Yu.S. Kovalev, A.V. Rogachev, N.I. Zamyatin, I.A. Kryachko</p>  |   |

**16. Development of neutron scattering methods for interdisciplinary studies of nanosystems and materials**

FLNP

**V.I. Bodnarchuk  
G.D. Bokuchava  
D.P. Kozlenko**

Data taking
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S.V. Kozhevnikov, Yu.V. Nikitenko, S.P. Yaradaikin,  
S.E. Kichanov, E.V. Lukin

**17. Development of the IBR-2 spectrometer complex**

FLNP

**A.M. Balagurov  
D.P. Kozlenko**

Realization
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M.V. Avdeev, A.I. Beskrovnyi, I.A. Bobrikov, A.I. Kuklin,  
V.I. Bodnarchuk, D.M. Chudoba, A.S. Doroshkevich,  
V.M. Morozov, D. Neov, Yu.V. Nikitenko, A.V. Petrenko,  
B.N. Savenko, V.G. Simkin, V.I. Sukhanov,  
G.D. Bokuchava, Ch. Scheffzuek

**Collaboration**

Country or International Organization	City	Institute or Laboratory
Argentina	Bariloche	CAB CNEA
Azerbaijan	Baku	AzTU
		IP ANAS
Belarus	Minsk	IAP NASB
		SPMRC NASB
		INP BSU
		BSTU
		RI PCP BSU
Bulgaria	Sofia	ASCT Ltd
		IE BAS
		IEES BAS
		IMS BAS
		INRNE BAS
		ISSP BAS
Czech Republic	Prague	CTU
		IG ASCR
		IMC ASCR
		IP ASCR
	Řež	NPI ASCR
Egypt	Cairo	EAEA
	Cairo	CU
France	Saclay	LLB
	Grenoble	IBS
Germany	Berlin	HZB
		BAM
	Bayreuth	Univ.
	Bochum	RUB
	Darmstadt	TU Darmstadt
	Dortmund	TU Dortmund



	Dresden	TU Dresden
	Göttingen	Univ.
	Geesthacht	GKSS
	Halle	MLU
	Hamburg	DESY
	Freiberg	TUBAF
		IMF TUBAF
	Jülich	FZJ
	Karlsruhe	KIT
	Kiel	CAU
		IFM-GEOMAR
	Leipzig	UoC
	Potsdam	GFZ
	Rostock	Univ.
	Stuttgart	MPI-FKF
Hungary	Budapest	Wigner RCP
	Szeged	US
India	Gurgaon	AMITY
Japan	Nagano	Shinshu Univ.
	Minato	Keio Univ.
Italy	Trento	UniTh
Latvia	Riga	ISSP UL
		IPE
Moldova	Chişinău	IMB ASM
		IC ASM
Kazakhstan	Rudny	RII
	Almaty	INP
Mongolia	Ulaanbaatar	IPT MAS
		MUST
Norway	Trondheim	NGU
Poland	Warsaw	INCT
	Krakow	JU
		AGH-UST
		NINP PAS
	Lublin	UMCS
	Olsztyn	UWM
	Otwock-Swierk	NCBJ
	Poznan	AMU
	Siedlce	UPH
	Szczecin	WPUT
	Wroclaw	WUT
		UW
Romania	Bucharest	IFIN-HH
		INCDIE ICPE-CA
		INFLPR

		NIMP
		ISS
		UB
		UPB
		UMF
		UTM
		CNMN
	Baia Mare	TUCN-NUCBM
	Constanța	UOC
	Craiova	UC
	Cluj-Napoca	INCDTIM
		RA BC-N
		UBB
		UTC-N
	Iași	USAMV
		NIRDTP
		UAI
		UAIC
	Pitești	SCN
		UPIT
	Timișoara	LMF CCTFA
		RA TB
		UPT
		UVT
Russia	Moscow	GC RAS
		IA RAS
		IBMC
		IC RAS
		IEPT RAS
		IGEM RAS
		IGIC RAS
		IMET RAS
		INMI RAS
		IPCE RAS
		ITEP
		IPE RAS
		ISPM RAS
		NNRU “MEPhI”
		MIET
		MITHT
		MISiS
		MSU
		NIKIET
		NRC KI
		SINP MSU

	Moscow, Troitsk	SC "VNINM" HPPI RAS ISAN INR RAS
	Belgorod Dolgoprudny Dubna	BelSU MIPT Diamant Dubna Univ.
	Chernogolovka Gatchina Kaliningrad Kazan Krasnoyarsk Nizhny Novgorod	ISSP RAS PNPI IKBFU KNRTU SibFU UNN IPM RAS
	Obninsk Perm	IPPE ICMM UrB RAS ITCh UrB RAS
	Petrozavodsk Podolsk Rostov-on-Don St. Petersburg	IG KRS RAS GIDROPRESS RIP SFU IPTI RAS SPbSU
	Sterlitamak Tomsk Tula Yekaterinburg	SSPA NPI TPU TSU IMP UB RAS UrFU
Serbia	Belgrade Novi Sad	INS "VINČA" UNS
Slovakia	Bratislava Košice	CU IEP SAS
South Africa	Pretoria	Necsa
Spain	Madrid	CENIM-CSIC
Switzerland	Villigen Zurich	PSI ETH
Tajikistan	Dushanbe	IChem ASRT
Taiwan	Hsinchu	NSRRC
Ukraine	Kiev	IPMS NASU NUK ISC NASU
	Donetsk	DonNU DonIPE
	Kharkov	IERT NASU KFTI

United Kingdom  
Uzbekistan  
Vietnam

Didcot  
Tashkent  
Hanoi  
Da Nang

RAL  
INP AS RUz  
IOP VAST  
DTU

04-4-1105-2011/2019

Priority:

1

Status:

Extended

## Development of the IBR-2 Facility with a Complex of Cryogenic Neutron Moderators

### Leaders:

A.V. Belushkin  
A.V. Vinogradov

### Participating Countries and International Organizations:

Argentina, Azerbaijan, Belarus, Czech Republic, Japan, Mongolia, Poland, Romania, Russia, Spain, United Kingdom, USA.

### Scientific Programme

The theme main task is to increase the efficiency of the use of the IBR-2 facility for realization of the program of experimental investigations, maintenance of operational reliability and safety of the reactor, creation of a complex of cryogenic neutron moderators.

#### Expected main results in 2017:

- Maintenance of the IBR-2 reactor operation for physical investigations.
- Manufacturing of a reserve movable reflector MR-3R (with the extension of work through 2018).
- Carrying out of experiments, development and construction of new units and equipment, optimization of operating modes on the test stand of the CM-201 cryogenic moderator.
- Step-by-step replacement and upgrading of the technological and electrical equipment in accordance with the Rostekhnadzor license requirements.

### List of projects:

Project	Leader	Priority (period of realization)
1. Construction of a Complex of Cryogenic Moderators at the IBR-2 Facility	A.A. Belyakov	1 (2014 – 2019)

### List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. Operation of the IBR-2 facility in the regular mode  FLNP	A.V. Dolgikh A.V. Vinogradov  A.A. Belyakov, S.A. Tsarenkov, V.G. Ermilov, S.V. Rudenko, Yu.N. Pepelyshev, V.A. Trepalin, + 30 engineers, + 50 workers	Realization

- |  |   |   |             |
|--|---|---|-------------|
| <p>2. <b>Maintenance of the program of physical investigations</b></p> <p>FLNP</p>   | <p><b>V.D. Ananiev</b><br/><b>A.V. Vinogradov</b><br/><b>A.V. Dolgikh</b></p> <p>A.A. Belyakov, Yu.N. Pepelyshev, V.A. Trepalin, S.V. Rudenko, + 30 engineers, + 50 workers</p> | <table border="1" style="margin: auto;"> <tr> <td>Realization</td> </tr> </table> | Realization |
| Realization  |   |   |             |
| <p>3. <b>Experiments on a test stand of the CM-201 cryogenic moderator. Manufacturing and installation of equipment and pipelines of the CM-201 cryogenic moderator (with the extension of work to 2018). Feasibility study of the cryogenic moderator CM-203. Mastering of the equipment of cryogenic moderators using a new cryogenic facility by “Linde” in its regular place</b></p> <p>FLNP</p> | <p><b>A.A. Belyakov</b><br/><b>K.A. Mukhin</b></p> <p>V.D. Ananiev, S.A. Kulikov, E.P. Shabalin, + 15 engineers, + 15 workers</p>   | <table border="1" style="margin: auto;"> <tr> <td>Realization</td> </tr> </table> | Realization |
| Realization  |   |   |             |
| <p>4. <b>Manufacturing of a reserve movable reflector MR-3R</b></p> <p>FLNP</p>  | <p><b>A.V. Vinogradov</b><br/><b>A.V. Dolgikh</b></p> <p>A.A. Belyakov, V.D. Ananiev, + 5 engineers, + 5 workers</p>  | <table border="1" style="margin: auto;"> <tr> <td>Realization</td> </tr> </table> | Realization |
| Realization  |   |   |             |
| <p>5. <b>Step-by-step replacement and upgrade of basic technological and electrical equipment</b></p> <p>FLNP</p>  | <p><b>A.V. Vinogradov</b><br/><b>A.V. Dolgikh</b></p> <p>A.A. Belyakov, A.V. Trepalin, + 30 engineers, + 50 workers</p>   | <table border="1" style="margin: auto;"> <tr> <td>Realization</td> </tr> </table> | Realization |
| Realization  |   |   |             |

## Collaboration

Country or International Organization	City	Institute or Laboratory
Argentina	Buenos Aires	CNEA
Azerbaijan	Baku	IRP ANAS NNRC
Belarus	Minsk	IAP NASB
Czech Republic	Řež Plzen	UJV “Skoda”
Japan	Sapporo Osaka	Hokkaido Univ. ISIR
Mongolia	Ulaanbaatar	MUST
Poland	Krakow	AGH-UST
Romania	Bucharest	IFIN-HH
Russia	Moscow	NIKIET Geliymash

Spain  
United Kingdom  
USA

Valencia  
Didcot  
Indianapolis, IN

INEUM  
SYSTEMATOM  
SSDI  
ENES  
Profimontazhservis  
UPV  
RAL  
IUPUI

## Development of Experimental Facilities for Condensed Matter Investigations with Beams of the IBR-2 Facility

**Leaders:** S.A. Kulikov  
V.I. Prikhodko

### Participating Countries and International Organizations:

Belarus, Bulgaria, Czech Republic, France, Germany, Hungary, Republic of Korea, Romania, Russia, Slovak Republic, Ukraine, United Kingdom.

### Scientific Programme

Development and construction of a control system of the cryogenic moderator CM-201 for IBR-2 beams № 1, 4, 5, 6, 9.

Design of equipment, electronics and software for the complex of IBR-2 spectrometers; development of the FLNP information and computing infrastructure according to the needs of the Laboratory and the development strategy of the JINR computer network.

#### Expected main results in 2017:

- Test operation and development of the CM-202 cryogenic moderator systems with a double cryostat and control systems. Experimental studies of radiation and moderating properties of novel advanced materials for cold moderators on the DIN-2PI spectrometer of IBR-2 and radiation research facility. Study and optimization of parameters of the CM-201 moderator on a test stand. Study of radiation resistance of magnetic sensors and detector materials.
- Development and use of the VITESS software package for simulation of reflectometric and GISANS experiments in the modified kinematic approximation; simulation of diffraction and diffuse scattering from multilayer structures with magnetic domains.
- Implementation of the project "Development of PTH sample environment system for the DN-12 diffractometer at the IBR-2 facility" (start-up and adjustment activities: creation of a temperature map for cryostat units with short-circuited current leads at the level of 77 K and 20 K; installation of a magnet in a horizontal position, generation of a magnetic field, measurement of characteristics of the magnet; installation of the cryostat with a sample into the cryostat of the magnet).
- Manufacturing of a monitor 2D PSD for the IBR-2 spectrometers and elements of the ASTRA-M detector system for the FSD spectrometer. Development of a PSD detector with boron convertor, investigation of its characteristics. Assembling and testing of a ring small-angle detector (RTD spectrometer). Equipping of a clean room in bldg. 119.
- Development, manufacturing and adjustment of the prototype of USB-3.0 interface module for MPD-16 electronic units of data acquisition systems of IBR-2 spectrometers. Assembling of 90°-detectors, adjustment of analog and digital electronics, testing of a detector system in different operation modes on the FSS diffractometer. Adaptation of 8-channel digital converter CAEN 6730 for processing data from one- and two-coordinate neutron position-sensitive detectors.
- Putting into operation of the control system of actuators on the basis of Huber goniometer for sample positioning on the FSS diffractometer and the control system of four power sources on the REMUR spectrometer. Design and prototyping of a new control system of the chopper on the basis of a stepper motor.



- Modernization and technical support of the Sonix+ software package, its adaptation to new versions of the software in use. Installation of Sonix+ on the FSS diffractometer. Integration of drivers of new equipment into Sonix+ and development of new programs of the software package at the requests of the users.
- Modernization of outdated network switches in FLNP buildings 42 and 42a for providing data transfer rate of 1 Gbits/s in all LAN nodes. Expansion of WiFi laboratory network.

### List of projects:

Project	Leader	Priority (period of realization)
1. Development of PTH sample environment system for the DN-12 diffractometer at the IBR-2 facility	A.N. Chernikov	1 (2015 – 2017)

### List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. Development of a control system of CM-201 moderator for neutron beams № 1, 4, 5, 6, 9  FLNP	S.A. Kulikov E.P. Shabalin  M.V. Bulavin + 5 engineers, + 7 workers, A.S. Kirilov + 2 engineers, A.P. Sirotin + 2 engineers	Realization
2. Calculations and simulation of spectrometers' elements. Development of the VITESS software package  FLNP	A.V. Belushkin  E S.A. Manoshin, S.A. Kulikov + 2 engineers	Realization
3. Development and manufacturing of new control and data acquisition electronics for the FSS spectrometer  FLNP	A.A. Bogdzel A.P. Sirotin  F.V. Levchanovsky + 2 engineers, N.D. Zernin	Realization
4. Development and implementation of gas-filled and scintillation detectors at the IBR-2 spectrometers  FLNP	A.V. Belushkin S.A. Kulikov  M.V. Avdeev, G.D. Bokuchava, A.I. Kuklin + 2 engineers, A.V. Churakov + 3 engineers, A.A. Bogdzel + 4 engineers, V.V. Zhuravlev, V.V. Kruglov, A.S. Kirilov + 1 engineer	Realization
5. Development of data acquisition, control and experiment automation systems, as well as of Sonix+ software package at the IBR-2 spectrometers  FLNP	V.I. Prikhodko A.P. Sirotin A.S. Kirilov  A.A. Bogdzel + 2 engineers, F.V. Levchanovsky + 2 engineers, V.V. Zhuravlev + 3 engineers, S.M. Murashkevich + 2 engineers	Realization

6. Creation of a cloud polygon  
 “neutron physics” in cooperation  
 with LIT; carrying out  
 computations using IaaS and SaaS  
 services. Development of FLNP  
 network infrastructure in  
 accordance with the development  
 strategy of the JINR computer  
 network

S.A. Kulikov  
 V.I. Prikhodko

Realization
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FLNP

G.A. Sukhomlinov + 2 engineers, A.S. Kirilov  
 + 2 engineers, S.A. Manoshin + 1 engineer

LIT

V.V. Korenkov + 2 engineers

## Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	BSTU
Bulgaria	Sofia	INRNE BAS
Czech Republic	Řež	NPI ASCR
France	Grenoble	ILL
	Saclay	LLB
Germany	Berlin	HZB
	Heidelberg	Univ.
	Magdeburg	OVGU
	Munich	TUM
	Karlsruhe	KIT
	Zeuthen	DESY
	Jülich	FZJ
Hungary	Budapest	Wigner RCP
Republic of Korea	Daejeon	NFRI
Romania	Bucharest	INCDIE ICPE-CA
		IFIN-HH
	Târgoviște	UVT
Russia	Moscow	NNRU “MEPhI”
		NRC KI
	Moscow, Troitsk	INR RAS
	Dubna	Dubna Univ.
	Gatchina	PNPI
	Yekaterinburg	IMP UB RAS
	Nizhny Novgorod	IPM RAS
Slovakia	Bratislava	IMS SAS
Ukraine	L’viv	LPNU
United Kingdom	Didcot	RAL

## Multimodal Platform for Raman and Nonlinear Optical Microscopy and Microspectroscopy for Condensed Matter Studies

**Leader:** G.M. Arzumanyan

### Participating Countries and International Organizations:

Armenia, Belarus, Germany, Latvia, Poland, Romania, Russia, France.

### Scientific Programme

Experimental studies of condensed matter by Raman, CARS (coherent antiStokes Raman spectroscopy), and SERS (surface-enhanced Raman spectroscopy) spectroscopy and microscopy. Research of structural and optical properties, surface morphology and other characteristics of condensed matter on the multimodal optical platform constructed on the basis of the confocal laser scanning microscope "CARS". Raman spectroscopy is a non-invasive, label-free technique which excites vibrations of molecular bonds. Since optical microscopy is highly valuable to biomedical research, special attention will be given to the spectral-structural studies of various biological samples using coherent and surface-enhanced Raman spectroscopy. Another research direction deals with a study of photo- and upconversion luminescence of optical matrices (glass, glass-ceramics, colloidal nanocrystals) activated by various rare-earth elements.

#### Expected main results in 2017:

- High contrast nonlinear chemical mapping of biosamples with a signal-to-noise ratio not less than 30:1 in the CARS and SERS options.
- First test-experiments aimed at achieving ultrahigh sensitivity on a single molecule detection level using coherent SERS modality.
- Revealing of molecular compositions and/or conformation changes that can occur in tissues during carcinogenesis or other pathologies.
- Completion of studies on structural and optical properties of transparent matrices based on ZnO nanocrystals codoped with rare earth elements.
- Plasmonic photo- and upconversion luminescence enhancement (not less than one order of magnitude) in phosphors activated with rare earth elements.
- Further development of the multimodal optical platform: utilization of 785nm laser excitation wavelength to suppress the autofluorescence background from samples under study.

### List of projects:

Project	Leader	Priority (period of realization)
1. Multimodal platform for Raman and nonlinear optical microscopy and microspectroscopy for condensed matter studies	N. Kučerka Deputy: V.I. Gordeliy	1 (2015 – 2017)

**List of activities:**

<b>Activity or experiment</b> Laboratory or other Division of JINR	<b>Leaders</b> Main researchers	<b>Status</b>
1. <b>Application of the method of CARS and SERS microscopy aimed at high-contrast chemical selective imaging of various compounds and significant enhancement of the Raman scattering signal from samples under investigation</b>  FLNP	<b>G.M. Arzumanyan</b> <b>N. Kučerka</b>  V.I. Gordeliy, K.Z. Mamatkulov, N.V. Doroshkevich, K.Sh. Voskanyan	Realization Data taking
2. <b>Development of nanostructured plasmon-enhanced Raman spectroscopy and microscopy method</b>  FLNP	<b>G.M. Arzumanyan</b>  K.Z. Mamatkulov, N.V. Doroshkevich, E.A. Kuznetsov	Data taking Simulation
3. <b>Investigation of phospholipid conformations in model membranes with Raman spectroscopy</b>  FLNP	<b>G.M. Arzumanyan</b> <b>N. Kučerka</b> <b>V.I. Gordeliy</b>  K. Mamatkulov, K.Sh. Voskanyan, N.V. Doroshkevich, K.O. Demeshenkova	Data taking
4. <b>A complex study of structural and spectral properties of optically transparent glasses and nanoglassceramics activated with various rare earth elements (REE)</b>  FLNP	<b>G.M. Arzumanyan</b>  E.A. Kuznetsov, N.V. Doroshkevich	Realization
5. <b>Upgrade of the software and development of the instrumental infrastructure of the optical platform to expand its capabilities and increase the measurement sensitivity.</b>  FLNP	<b>G.M. Arzumanyan</b> <b>N. Kučerka</b>  K. Mamatkulov, I.A. Morkovnikov, M.L. Korobchenko	Upgrade

**Collaboration**

<b>Country or International Organization</b>	<b>City</b>	<b>Institute or Laboratory</b>
Armenia	Yerevan	Inst. Physiology NAS RA
Belarus	Minsk	BSUIR SOL instruments

Germany	Jülich	Institute of Physiology NASB
Latvia	Riga	FZJ
Poland	Lublin	ISSP UL
Russia	Moscow	UMCS
	Dolgoprudny	GPI RAS
	St. Petersburg	MIPT
Romania	Bucharest	NITIOM
		IFIN-HH
		UPB
France	Grenoble	IBS
Ukraine	Donetsk	DonNU

## Radiation Physics, Radiochemistry, and Nanotechnology Investigations Using Beams of Accelerated Heavy Ions

### Leaders:

S.N. Dmitriev  
P.Yu. Apel

### Participating Countries and International Organizations:

Belarus, Bulgaria, China, Cuba, Czech Republic, Egypt, Germany, India, Kazakhstan, Moldova, Mongolia, Poland, Romania, Russia, Serbia, Slovak Republic, South Africa, Spain, Ukraine, United Kingdom, USA, Vietnam.

### Scientific Programme

Transition to a new level of research and development in the fields of radiation solid state physics, applied radiochemistry and materials science, with a prospect of to nanotechnology applications. The main emphasis will be on the modification of the materials at the nanometer scale and on the study of the effects produced by heavy ions in matter with the aim of revealing the fundamental mechanisms and of the development of nanotechnology applications for ion beams. Modernization of the FLNR facilities for the production of medical isotopes and development of materials modification methods.

#### Main results expected in 2017:

- Determination of the threshold electronic stopping powers for latent track formation and study of track region morphology in Y-Al, Y-Ti and Ti oxide crystals using high-resolution transmission electron microscopy.
- Study of structural changes induced by heavy ions of fission fragment energy in oxide and carbide nanoparticles in oxide dispersion-strengthened alloys.
- Registration and measurement of structure characteristics of heavy ion latent tracks in polymers using scanning probe tomography.
- Study of effects of high-energy ion bombardment in 2D-materials.
- Study of giant magnetic resistance in metal nanowires obtained using template synthesis in track-etched nanopores.
- Investigation of osmotic phenomena in nanochannels obtained by the track etching technique. Development of a convection-diffusion model for electrolyte transport in track-etched nanopores.
- Development of methods for coating track membranes with SERS-active layers aimed at creation of high-sensitivity membrane sensors.
- Study of mass transport processes under electrical field in hydrophobic nanochannels.
- Application of the method of recoil nuclei for separation and concentration of radioactive isotopes  $^{99}\text{Mo}$ ( $^{99}\text{Tc}$ ),  $^{225}\text{Ac}$ ,  $^{236}\text{Np}$ , development of synthesis according to reaction  $(\gamma, n)$   $^{64}\text{Cu}$ ,  $^{196}\text{Au}$  for nuclear medicine and environmental studies.
- Study of distribution of trace elements and radionuclides of the natural series of U and Th in ecosystems (Mongolia, South Africa).

## List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. Investigations of radiation damages in solids and formation of nanostructures  FLNR	V.A. Skuratov P.Yu. Apel  V.K. Semina, O.L. Orelovich, V.V. Shirkova, A.N. Nechaev, I.V. Blonskaja, L.I. Kravets, O.M. Ivanov, D.V. Shchegolev, Yu.K. Kochnev, V.A. Altynov, O.V. Kristavchuk, N.S. Kirilkin, E.A. Korneeva, V.F. Reutov	Data taking
LIT FLNP	V.V. Trofimov A.I. Kuklin, M.V. Frontasyeva	
2. Production of ultra-pure isotopes  FLNR	S.N. Dmitriev  O.D. Maslov, G.Ya. Starodub, A.V. Sabelnikov, Yu.V. Albin, G.A. Bozhikov, G.K. Vostokin, M.V. Gustova, T.P. Drobina	Manufacturing
3. Radioanalytical studies  FLNR	O.D. Maslov  O.D. Maslov, A.V. Sabelnikov, M.V. Gustova, T.P. Drobina	Data taking
4. Construction of accelerator complexes for nuclear medicine and radiation physics research  FLNR DLNP	S.N. Dmitriev A.A. Chumbalov  B.N. Gikal, I.V. Kolesov, A.A. Chumbalov A.G. Molokanov	Designing Manufacturing

## Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	BSU
		INP BSU
	Gomel	RIAPP BSU
		BNTU
		GEI
Bulgaria	Plovdiv	GSU
China	Beijing	PU
		Beijing Fert Co
Cuba	Havana	PKU
		CEADEN
Czech Republic	Brno	BUT
	Prague	CU
		NORM Free s.r.o.

	Řež	NPI ASCR
Egypt	Cairo	TIMS
Germany	Darmstadt	GSI
	Quedlinburg	IST
		MiCryon Technik
Kazakhstan	Almaty	INP
		IPT
	Astana	ENU
		NU
Moldova	Chişinău	IAP ASM
Mongolia	Ulaanbaatar	NRC NUM
		NUM
Poland	Warsaw	ITR
		INCT
	Lublin	UMCS
	Otwock-Swierk	NCBJ
	Torun	UMK
Russia	Chernogolovka	ISSP RAS
		BInEPCP RAS
	Dubna	Trackpore Technology
	Krasnodar	KSU
	Moscow	IC RAS
		GPI RAS
		ISPM RAS
		MATI
		MIEM
		RIVS
		SINP MSU
		LPI RAS
		MUCTR
		Technomedexport
		MSMU
	Novosibirsk	ISP SB RAS
	Obninsk	REATRACK- Filter
	St. Petersburg	IPTI RAS
	Simferopol	SIMPEX
		MALDAS
	Vladimir	Vladisart
Romania	Bucharest	INFLPR
Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	BIONT
		CU
		IEE SAS



South Africa	Port Elizabeth	NMMU
	Bellville	UWC
Spain	Madrid	IA-CSIC
	Valencia	UV
Ukraine	Kharkov	IERT NASU
United Kingdom	London	Middlesex Univ.
USA	Stanford, CA	SU
	Knoxville, TN	UTK
	Oak Ridge, TN	ORNL
	Hanoi	IOP VAST
Vietnam		

## Research on the Biological Effect of Heavy Charged Particles with Different Energies

**Leaders:**

E.A. Krasavin  
G.N. Timoshenko

**Participating Countries and International Organizations:**

Armenia, Belarus, Bulgaria, Czech Republic, Egypt, Italy, Moldova, Mongolia, Poland, Romania, Russia, Slovak Republic.

**Scientific Programme**

Theoretical and experimental research on the biological effect of heavy charged particles with different energies at JINR's basic facilities.

The research and development will include:

- Research on the regularities and mechanisms of the initiation of molecular disorders in the DNA structure and their repair; and radiation-induced apoptosis in human cells under exposure to radiations with different linear energy transfer (LET).
- Decoding of the mechanisms underlying cell hypersensitivity and hyperresistance to low doses of ionizing radiation.
- Acquisition of comparative data on the regularities of the induction of gene and structural mutations in mammalian and lower eukaryote cells by sparsely and densely ionizing radiations with different LET.
- Research on the mechanisms of the induction of retinal damage by heavy charged particles (HCP) and its repair.
- Research on the character of the HCP-induced damage of central nervous system (CNS) cells and regularities of their death. Identification of HCP-induced functional and morphological disorders in the CNS.
- Mathematical modeling of the effects induced by ionizing radiations with different LET at the molecular and cellular levels. Development and analysis of mathematical models of the molecular mechanisms of CNS structural and functional disorders induced by ionizing radiations.
- Calculation of the radiation shielding of new nuclear physics facilities; evaluation of the radiation environment and development of radiation safety systems.

**Expected main results in 2017:**

- To continue studying regularities in the induction, formation, and repair kinetics of HCP-induced clustered DNA double-strand breaks (DSBs) in human skin fibroblast nuclei.
- To study the expression of the genes encoding the proteins RAD51, DNA PKcs, NBS1, and MRE11, which participate in HCP-induced damage repair in human fibroblasts.
- To continue studying radiation-induced apoptosis mechanisms and different ways of HCP-induced DNA damage repair. To study the expression of the genes that encode the proteins and caspases participating in apoptosis induction in human fibroblasts by HCP.
- Using a Synergy H1m microplate reader, to evaluate the level of the reactive oxygen species and ERK protein kinase in mammalian microglial cells exposed to protons and HCP.

- To continue studying regularities in the induction of gene and structural mutations in yeast cells by radiations with different LET.
- To continue research on the mutagenic effect of ionizing radiations on mammalian cells in the remote after irradiation. To complete a molecular analysis of HPRT-mutant subclones.
- To continue studying the mechanisms behind retina recovery: Mueller cell activation, expression of endogenous protectors in the retina, and expression of the oxidative stress proteins.
- To continue research on the apoptotic death of neurons in different sections of the rat and mouse brain at different times after exposure to radiations with different LET.
- To continue studying disorders in the exchange of monoamines and their metabolites in the prefrontal cortex, hippocampus, striatum, adjoining nucleus, and hypothalamus of the rat brain under exposure to ionizing radiations.
- To continue the development of mathematical models of neurons' functional activity under exposure to radiations with different LET.
- To continue elaboration of model approaches to the quantitative estimation of the relation between the plastic processes in neurons participating in the formation of the brain's functional networks.
- To continue the development of mathematical models of the axon transport of signals.
- To continue testing and calibration of nuclear planetary science instruments with fast neutron generators at the LRB's test site.
- To ensure the conduction of the radiobiological experiments at the Nuclotron (the Laboratory of High-Energy Physics), U-400M cyclotron (the Laboratory of Nuclear Reactions), and the medical beam of the Phasotron (the Laboratory of Nuclear Problems).

### List of projects:

Project	Leader	Priority (period of realization)
1. Research on the biological effect of heavy charged particles with different energies	E.A. Krasavin G.N. Timoshenko	1 (2015 – 2017)

### List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. Radiobiological research at charged particle beams	E.A. Krasavin	Data taking Realization Data taking

LRB

S.V. Aksenova, G.F. Aru, K.V. Belokopytova, O.V. Belov, P. Blaha, Yu.V. Bogdanova, A.V. Boreyko, A.N. Bugay, N.N. Budennaya, T.S. Bulanova, V.N. Chausov, E.B. Dushanov, D.V. Elsha, T.B. Feldman, R.D. Govorun, E.V. Ilyina, A.A. Ivanov, L. Jezkova, A.N. Kokoreva, E.A. Kolesnikova, N.A. Koltovaya, O.V. Komova, I.V. Koshlan, N.A. Koshlan, M.A. Kovalenko, P.V. Kutsalo, E.A. Kuzmina, V.N. Lisy, K.N. Lyakhova, B. Munkhbaatar, E.A. Nasonova, S.S. Negovelov, M.A. Ostrovsky, M.S. Panina, A.Yu. Parkhomenko, Yu.S. Severyukhin, N.L. Shmakova, E.V. Smirnova, S.I. Tiunchik, V.A. Tronov, D.M. Utina, M.A. Vasilyeva, Yu.V. Vinogradova, M.G. Zadnepryanets, N.I. Zhuchkina, + 3 engineers, + 7 workers

**2. Radiation research**

**G.N. Timoshenko**

Preparation Data taking R&D
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LRB

V.E. Aleinikov, L.G. Beskrovnaya, A.R. Krylov, V.A. Krylov, E.N. Lesovaya, + 10 engineers, + 2 workers

**3. Training activity**

**E.A. Krasavin**  
**S.Z. Pakuliak (UC)**

LRB

V.E. Aleinikov, O.A. Bakerin, O.V. Belov, A.V. Boreyko, N.N. Budennaya, T.B. Feldman, R.D. Govorun, A.A. Ivanov, N.A. Koltovaya, O.V. Komova, M.M. Komochkov, I.V. Koshlan, M.A. Ostrovsky, A.Yu. Parkhomenko, G.N. Timoshenko

**Collaboration**

**Country or International Organization**

**City**

**Institute or Laboratory**

Armenia

Yerevan

YSU

Belarus

Gomel

IRB NASB

Minsk

IP NASB

Bulgaria

Sofia

IE BAS  
INRNE BAS  
NCRRP

Czech Republic

Brno

IBP ASCR

Prague

CTU

Řež

NPI ASCR

UJV

Egypt

Giza

CU

Italy

Udine

Uniud

Moldova

Chişinău

UnASM

Mongolia

Ulaanbaatar

NUM

Poland

Szczecin

US

Romania

Bucharest

UMF

ISS

	Iași	UAIC
		IBR
Russia	Moscow	IBMP RAS
		IHNA Ph RAS
		SF IPh
		ITEP
		MSU
	Astrakhan	ASU
	Sochi	SRI MP
	Vladivostok	FEFU
Slovakia	Bratislava	CU

## **Research on Cosmic Matter on the Earth and in Nearby Space; Research on the Biological and Geochemical Specifics of the Early Earth**

**Leaders:**

E.A. Krasavin  
A.Yu. Rozanov  
V.N. Shvetsov

**Participating Countries and International Organizations:**

Italy, Norway, Poland, Romania, Russia, United Kingdom, USA.

**Scientific Programme**

Research and development will include:

- Biogeochemical studies of cosmic dust
- Studies of biofossils and organic compounds in meteorites and ancient terrestrial rocks
- Studies of cosmic matter with nuclear physics methods
- As a result of studying and generalizing the research materials on modern and fossil cosmic dust as well as ancient terrestrial objects and modern organisms of the extreme ecosystems, data will be obtained on the forms of ancient terrestrial and extraterrestrial life.

As the results:

- Obtaining new data on the amount of cosmic matter falling on the whole Earth's surface. Obtaining data on the dynamics of cosmic dust fallout on large territories.
- Evaluation of the following parameters of particles of extraterrestrial origin: morphology, structure, size distribution, and elemental, isotopic, and mineralogical composition. Assessment of changes in these characteristics in different plates in different time intervals.
- Creation of a cosmic dust collection, where dust microparticles will be characterized by quantity (concentration) and the size distribution.
- Obtaining new information on the role of microorganisms in the formation and evolution of life on the Earth and processes of weathering, precipitation growth, etc.
- Research on the synthesis of complex prebiotic compounds from formamide under exposure to ionizing radiations of different qualities with meteorite samples as catalysts.
- Generalization of the obtained data on the forms of ancient terrestrial and, possibly, extraterrestrial life.

**Expected main results in 2017:**

- To continue the detection and study of biofossils and organic matter in meteorites and the most ancient terrestrial rocks.
- To continue the diagnostics of microorganism remnants in Archaean and Proterozoic rocks and evaluation of their organization level with nuclear physics methods.
- To continue research on the synthesis of complex prebiotic compounds from formamide under exposure to accelerated ions with different linear energy transfer.
- To study the nature of the catalysts participating in the synthesis of complex prebiotic compounds from formamide.

## List of projects:

Project	Leader	Priority (period of realization)
1. Research on cosmic matter on the Earth and in nearby space; research on the biological and geochemical specifics of the early Earth	E.A. Krasavin Scientific leader: A.YU. Rozanov	1 (2013 – 2019)

## List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. <b>Studies of microfossils in meteorites and ancient terrestrial rocks</b>	<b>A.Yu. Rozanov</b> <b>E.A. Krasavin</b>	Data taking Realization Simulation
LRB	M.M. Astafyeva + 1 engineer	
2. <b>Research on the synthesis of complex prebiotic compounds from formamide</b>	<b>R. Saladino</b>	Data taking Realization Simulation
LRB	M.I. Kapralov + 1 student	
3. <b>Biogeochemical and biological studies of cosmic dust</b>	<b>L.M. Gindilis</b>	Data taking Realization Simulation
LRB	I.A. Bobrikov + 2 engineers	
4. <b>Cosmic matter research with nuclear physics methods</b>	<b>V.N. Shvetsov (FLNP)</b>	Data taking Realization Simulation
FLNP	A.Yu. Dmitriev, M.V. Frontasyeva, P.V. Sedyshev	

## Collaboration

Country or International Organization	City	Institute or Laboratory
Italy	Rome	Univ. "La Sapienza"
	Viterbo	UNITUS
Norway	Trondheim	NTNU
Poland	Poznan	AMU
Romania	Bucharest	UB
	Iași	UAIC
Russia	Moscow	IGEM RAS
		IKI RAS
		MSU
		PIN RAS
		SAI MSU

United Kingdom  
USA

Borok  
Gatchina  
Novosibirsk  
Buckingham  
Athens, AL

IPE RAS  
PNPI  
BIC SB RAS  
UB  
ASU



## Biomedical and Radiation-Genetic Studies Using Different Types of Ionizing Radiation

**Leader:** G.V. Mitsyn  
**Deputy:** S.V. Shvidky

**Participating Countries and International Organizations:**  
 Czech Republic, India, Poland, Romania, Russia.

### Scientific Programme

Medico-biological and clinical research for the proton radiotherapy of cancer patients. Formation of experimental data base in the field of radiation mutagenesis in the animal germ cells.

#### Expected main results in 2017:

- Continuation of clinical researches on proton therapy of cancer patients in Room 1. Evaluation of the effectiveness of the conducted radiation treatment of different neoplasms.
- Work to increase the functional capability of the developed 3D treatment planning software and its clinical tests in the treatment sessions.
- Test of the prototype equipment for the dynamic conformal irradiation of deep-seated tumours with the proton beam.
- Development and improvement of detectors and tools for the clinical dosimetry of the medical hadron beams.
- Exploration of the possibilities of laser radioprotection against damage after exposure to ionizing radiation on mouse fibroblast cells with the application of laser module with a wave length of 532 nm.
- Investigations of the molecular spectra of gene mutations induced by different quality ionizing radiation in animal germ cells.

### List of projects:

Project	Leader	Priority (period of realization)
1. Further development of methods, technologies, schedule modes and delivery of radiotherapy	G.V. Mitsyn	1 (2017 – 2019)
2. RADIOGENE: Experimental justification of radiation genetic risk estimation according to the frequency of heritable DNA changes in human and animal structural genes	I.D. Alexandrov	1 (2017 – 2019)

## List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Further development of methods, technologies, schedule modes and delivery of radiotherapy  DLNP	G.V. Mitsyn K.Sh. Voskanyan  A.V. Agapov, I.V. Alexandrova, V.M. Breyev, D.M. Borovich, V.N. Gaevsky, G.V. Donskaya, Ye.I. Luchin, I.I. Klochkov, I.Ye. Miller, A.G. Molokanov, K. Oancea, S.A. Pisareva, M.A. Tseytlina, K.N. Shipulin, A.V. Rzyanina	R&D
2. RADIOGENE: Experimental justification of radiation-genetic risk estimation according to the frequency of heritable DNA changes in human and animal structural genes  DLNP	I.D. Alexandrov  M.V. Alexandrova, K.P. Afanasyeva, S.V. Korablinova, L.N. Korovina, Ye.V. Kravchenko, A.N. Rusakovich	R&D

## Collaboration

Country or International Organization	City	Institute or Laboratory
Czech Republic	Řež	UJV
	Prague	PTC
India	Mumbai	BARC
	New Delhi	IUAC
Poland	Krakow	NINP PAS
	Otwock-Swierk	NCBJ
	Poznan	GPCC
Romania	Bucharest	UMF
		UB
Russia	Moscow	VIGG RAS
		IBMP RAS
		RMAPE
	Dubna	RDH-9
	Rostov-on-Don	SFedU

## Novel Semiconductor Detectors for Fundamental and Applied Research

**Leader:** G.A. Shelkov  
**Deputy:** A.S. Zhemchugov

### Participating Countries and International Organizations:

CERN, Czech Republic, Germany, New Zealand, Poland, Russia, South Africa, Ukraine.

### Scientific Programme

Generic R&D of semiconductor radiation-resistant detectors based on new materials and of hybrid pixel detectors with high resolution for nuclear and particle physics. Development of the research infrastructure for semiconductor detector R&D, coupled with beam tests at the JINR facilities, to be used by groups from JINR and from the Member States. Scientific collaboration with research groups from other fields in feasibility studies of application of the newly developed detectors in others areas of science and technology (primarily in medicine and geology). Research in condensed matter physics using the method of positron annihilation spectroscopy (PAS). Development of a PAS method on the beam of monochromatic positrons, the creation of equipment for spectroscopy by the Doppler method of measuring the lifetime of positrons in matter.

#### Expected main results in 2017:

- Systematic studies of radiation hardness and response of GaAs detectors in the beams of the JINR facilities.
- Production of prototypes of Timepix hybrid pixel detectors with GaAs sensor of thickness less than 1 mm. Study of their capabilities in detecting neutrons, fission fragments and charged tracks.
- Production of a prototype of the low-background GaAs-based hybrid pixel detector for TGV-2.
- Study of X-ray contrast media identification by spectral data.
- MARS-CT calibration and image processing aimed at geophysics studies.
- Test of the block of registration for an electromagnetic calorimetry.
- Project preparation about use of new semiconductor photodetectors in a calorimetry for high energy physics.
- Commissioning of the slow monochromatic positrons cryogenic source, construction of the closed autonomous cooling system and the emitter-source of the activity of 30 mCi.
- The construction and commissioning of the specialized monochromatic positron channel (SMPC) and the experimental station. Start of research by Doppler method.

### List of projects:

Project	Leader	Priority (period of realization)
1. Novel semiconductor detectors for fundamental and applied research	G.A. Shelkov	1 (2015 – 2017)
2. LEPTA: Development of the experimental techniques and applied research with slow monochromatic positron beams	A.G. Kobets P. Horodek <b>Scientific leader</b> I.N. Meshkov	1 (2016 – 2017)

## List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Project "Novel semiconductor detectors for fundamental and applied research"	<b>G.A. Shelkov</b>	Realization
DLNP	A. Gongadze, M.I. Gostkin, A.V. Guskov, D.V. Dedovich, S. Shakur, S.A. Kotov, D.F. Kozhevnikov, V.G. Kruchonok, V.N. Pavlov, S.Yu. Porokhovoy, I.N. Potrap, L. Zavorka	
FLNP	Yu.N. Kopach, G. Akhmedov, S.Yu. Telezhnikov	
VBLHEP	J. Lukstins, A.M. Korotkova, D.O. Krivenkov, A.V. Averianov, C.B. Starikova	
2. Use of new semiconductor photodetectors in a calorimetry for high energy physics	<b>N.V. Anfimov</b>	Realization
DLNP	Z.V. Krumshcheyn, A.I. Antoshkin, A.G. Olshevskiy, I.A. Orlov, T.V. Rezinko, A.V. Rybnikov, A.S. Selunin, V.V. Chalyshev, I.E. Chirikov-Zorin, D.V. Fedoseev	
VBLHEP	I.A. Tyapkin, Z.Ya. Sadygov, T.Yu. Bokova, B. Marinova	
3. LEPTA Project: Development of the experimental techniques and applied research with slow monochromatic positron beams	<b>A.G. Kobets</b> <b>P. Horodek</b>	Realization
DLNP	E.V. Ahmanova, M.K. Eseev, I.N. Meshkov, O.S. Orlov, A.Yu. Rudakov, A.A. Sidorin, L.V. Soboleva, T.A. Stepanova, V.I. Hilinov, S.L. Yakovenko	
VBLHEP	V.M. Drobin, V.V. Seleznev	

## Collaboration

Country or International Organization	City	Institute or Laboratory
Czech Republic	Prague	CTU
CERN	Geneva	CERN
Germany	Hamburg	DESY
New Zealand	Christchurch	UC
Poland	Krakow	NINP PAS
Romania	Bucharest	ISS
Russia	Dubna	Dubna Univ.
	Moscow	MSU
		ITEP
	Moscow, Troitsk	INR RAS

South Africa  
Ukraine

Arkhangelsk  
Tomsk  
St. Petersburg  
Cape Town  
Kharkov

NArFU  
TSU  
SPbSPU  
iThemba LABS  
ISMA NASU  
IERT NASU



Networking,  
Computing,  
Computational  
Physics  
(05)

## Information and Computing Infrastructure of JINR

**Leader:** V.V. Korenkov  
**Deputy:** T.A. Strizh

### Participating Countries and International Organizations:

Armenia, Azerbaijan, Belarus, Bulgaria, CERN, China, Cuba, Czech Republic, Egypt, France, Georgia, Germany, Italy, Kazakhstan, Moldova, Mongolia, Poland, Romania, Russia, Slovakia, South Africa, Sweden, Taiwan, Ukraine, USA.

### Scientific Programme

The purpose of the theme is to ensure the further development of the network, information and computing infrastructure of JINR for the research and production activities of the Institute and its Member States on the basis of state-of-the-art information technologies in accordance with the JINR Seven-Year Plan of development. A particular area within the theme is the development of the Multifunctional information and Computing Complex (MICC) at LIT JINR presented in a Project form.

#### Expected main results in 2017:

- Modernization and increase of reliability of the central telecommunication node of the Institute's IT infrastructure, provision of the reliable operation of the JINR local network. A gradual transition of the JINR Backbone to 100 GBps.
- Modernization of the power supply system and uninterrupted power supply, air-conditioning and ventilation, fire safety complex and engineering infrastructure of MICC.

The introduction and use of new data transfer protocols, upgrade of the e-mail service, the development of the WiFi authorization service, designing of the "Personal Cabinet" service.

Increase of performance and storage capacity of the base grid component MICC – Tier-1 centre for the CMS experiment at JINR.

The extension of the computing resources and data storage systems which are part of the integral component Tier-2/CICC: 37% for processor capacity and 10% - for disk storage.

Increasing of the computing power of both a multi-core component of the HybriLIT cluster comprising multicore processors and co-processors Intel Xeon Phi, and a GPU component containing computation accelerators Nvidia. Increase in computing resources and disk storage HybriLIT up to 90 Tflops and 20 TB, respectively.

Growth of the cloud component capacity - increase in the number of cores up to 1400, memory – up to 6160 GB and disc storage - up to 576 TB.

The creation of a prototype for transferring the monitoring system to a new Icinga2 core and migration of the monitoring system to a new Icinga2 core. Commissioning of a new service monitoring system and analyzing of a possibility of events prediction.

The creation of the element of the LIT cluster for processing up to 0.5 PB and storing up to 1 PB data per year using the available resources for the computer off-line complex of data handling for the NICA project. Designing of the MICC computing component for NICA. Simulation of the computing centre for NICA in order to determine a required equipment configuration.

- Implementing a final stage of activities on transition of self-sustaining units to work in the system 1C UPP 8.3; integration of the 1C UPP system and subsystem Gateway (data bus); analysis of the special features and functionality of the platform 1C:ERP Enterprise Management 2, preparation for the transition from 1C UPP 8.3 to the platform 1C:ERP.



The completion of the implementation of a universal gateway for data exchange between different CIS subsystems.

The development of a multi-project version of the JINR corporate project management system (JINR CPMS) on the basis of a control system of the NICA project (APT EVM for NICA).

The development and functional implementation of the automated configuration, monitoring and control of the process of documents approval within the electronic document management system "EDMS Dubna".

The installation of a single window system: designing a Personal Cabinet system that provides end users with access to their personal information and implements a unified entry point to CIS; development of a web-portal to access a catalogue (a set of references) of the existing (ADB2, PIN, Indico, PM, HelpDesk, etc.) and future services; the development of detailed requirements for integration of the CIS subsystems with a single point of authorization and a database of the Personal Cabinet of JINR users.

- Training courses (tutorials) on distributed, cloud, and parallel programming technologies on the basis of the educational and research grid-infrastructure and the heterogeneous cluster 'HybriLIT': regular training courses on advanced IT technologies both for the JINR staff members and for students and young scientists from JINR Member States in frames of the practical courses organized by the JINR UC; special courses of the leading software developers; special courses and seminars in frames of conferences and schools organized by JINR; special courses in the JINR Member States in frames of programs for international cooperation.

### List of projects:

Project	Leader	Priority (period of realization)
1. MICC	V.V. Korenkov	1 (2017 – 2019)

### List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers
1. MICC Project	V.V. Korenkov A.G. Dolbilov V.V. Mitsyn T.A. Strizh
LIT	G. Adam, G. Adamov, Eu.I. Aleksandrov, I.N. Aleksandrov, K.N. Angelov, N.S. Astakhov, A.S. Baginyan, A.I. Balandin, N.A. Balashov, A.V. Baranov, S.D. Belov, D.V. Belyakov, A.S. Bondyakov, A.I. Churin, S.V. Chashchin, S.V. Gavrilov, A.P. Gavrish, V.V. Galaktionov, T.M. Goloskokova, A.O. Golunov, Eu.A. Grafov, N.I. Gromova, A.E. Gushchin, I.S. Kadochnikov, A.S. Kamensky, V.A. Kapitonov, I.A. Kashunin, A.O. Kondratiev, G.A. Korobova, E.Yu. Kulpin, N.A. Kutovskiy, A.A. Lavrentiev, S.B. Marchenko, M.A. Matveev, S.V. Mitsyn, A.V. Nechaevsky, D.A. Oleynik, G.A. Ososkov, I.S. Pelevanyuk, A.Sh. Petrosyan, M.S. Plyashkevich, D.V. Podgainy, L.A. Popov, D.I. Pryakhina, Ya.I. Rozenberg, T.F. Sapozhnikova, R.N. Semenov, M.L. Shishmakov, O.I. Streltsova, E.A. Tikhonenko, V.V. Trofimov, N.N. Voitishin, A.S. Vorontsov, A.V. Uzhinskiy, A.Yu. Zakomoldin, V.E. Zhiltsov, P.V. Zrelov, M.I. Zuev

VBLHEP  
Yu.K. Potrebenikov

FLNP  
G.A. Sukhomlinov

LRB  
V.N. Chausov

FLNR  
V.V. Sorokoumov

DLNP  
Yu.P. Ivanov

BLTP  
A.A. Sazonov

UC  
I.N. Semeniushkin

**2. Information and software support  
of the research-and-production  
activity at JINR**

LIT

SOICO  
N.A. Russakovich

VBLHEP  
Yu.K. Potrebenikov

**3. Development of a system of  
training and advanced training of  
IT professionals based on  
educational and research  
infrastructure and creation of an  
information system to provide  
assistance to users (Helpdesk)**

LIT

B.G. Shchinov, Yu.P. Minaev, O.V. Rogachevsky,  
S.V. Shmatov

A.G. Polyakov

**P.V. Zrelov  
V.V. Korenkov  
I.A. Filozova**

T.O. Ablyazimov, N.A. Balashov, A.V. Baranov,  
D.V. Belyakov, A.A. Bogolubskaya, N.A. Davyudova,  
S.V. Duchits, V.P. Gerdt, T.M. Goloskokova, D.S. Golub,  
N.V. Jerusalemova, L.A. Kalmykova, A.A. Karlov,  
D.V. Kekelidze, S.A. Kretova, S.V. Kunyaev,  
G.A. Kurmaeva, N.A. Kutovskiy, A.A. Kutovskaya,  
O.G. Melnikova, G.G. Musulmanbekov, S.A. Nechitailo,  
E.A. Paschenko, V.V. Pervushov, M.S. Plyashkevich,  
E.Yu. Polyakova, L.V. Popkova, A.V. Prikhodko,  
V.M. Pushkina, A.M. Raportirenko, A.P. Sapozhnikov,  
T.F. Sapozhnikova, S.V. Semashko, R.N. Semenov,  
A.V. Sheyko, G.V. Shestakova, D.B. Stankus,  
V.A. Stepanenko, T.S. Syresina, N.N. Vorobieva,  
V.M. Yagafarova, A.G. Zaikina, T.N. Zaikina

V.F. Borisovskiy

A.V. Philippov, K.V. Turusina

**V.V. Korenkov  
T.A. Strizh  
O.I. Streltsova**

N.A. Balashov, A.V. Baranov, S.D. Belov,  
V.V. Galaktionov, T.M. Goloskokova, N.I. Gromova,  
I.S. Kadochnikov, D.V. Kekelidze, N.A. Kutovskiy,  
V.V. Mitsyn, S.V. Mitsyn, I.K. Nekrasova,  
A.V. Nechaevsky, D.A. Oleynik, A.Sh. Petrosyan,  
D.V. Podgainy, T.F. Sapozhnikova, R.N. Semenov,  
V.V. Trofimov, A.V. Uzhinskiy, V.E. Zhiltsov, M.I. Zuev

UC  
S.Z. Pakuliak

## Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	YSU IIAP NAS RA
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	INP BSU JIPNR-Sosny NASB
Bulgaria	Sofia	INRNE BAS SU
CERN	Geneva	CERN
China	Beijing	IHEP CAS
Cuba	Havana	UCI
Czech Republic	Prague	IP ASCR
Egypt	Giza	CU
France	Marseille	CPPM
Georgia	Tbilisi	GRENA TSU GTU
Germany	Darmstadt Frankfurt/Main Hamburg Karlsruhe Zeuthen	GSI Univ. DESY KIT DESY
Italy	Bologna	INFN
Kazakhstan	Astana	ENU
Moldova	Chişinău	ASM IAP ASM RENAM
Mongolia	Ulaanbaatar	NUM
Poland	Krakow	CYFRONET
Romania	Bucharest Cluj-Napoca	IFA IFIN-HH INCDTIM
Russia	Moscow	IITP RAS ISP RAS ITEP KIAM RAS MPEI MSU RCC MSU RIPN

		NRC KI
		RSCC
		SINP MSU
	Moscow, Troitsk	INR RAS
	Chernogolovka	SCC IPCP RAS
		LITP RAS
	Dubna	Dubna Univ.
		SEZ "Dubna"
		SCC "Dubna"
	Gatchina	PNPI
	Nizhny Novgorod	UNN
	Novosibirsk	BINP SB RAS
	Pereslavl-Zalesskiy	PSI RAS
	Protvino	IHEP
	Puschino	IMPB RAS
	Samara	SSAU
	St. Petersburg	FIP
		ITMO
		SPbSU
		SPbSPU
Slovakia	Košice	IEP SAS
	Prešov	PU
South Africa	Cape Town	UCT
Sweden	Lund	LU
Taiwan	Taipei	ASGCC
USA	Arlington, TX	UTA
	Batavia, IL	Fermilab
	Upton, NY	BNL
Ukraine	Kiev	BITP NASU
	Kharkov	KFTI

## Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data

### Leaders:

Gh. Adam  
P.V. Zrelov

### Participating Countries and International Organizations:

Armenia, Australia, Azerbaijan, Belarus, Belgium, Brazil, Bulgaria, Canada, CERN, China, Czech Republic, France, Georgia, Germany, Greece, India, Italy, Japan, Kazakhstan, Moldova, Mongolia, Poland, Portugal, Romania, Russia, Slovakia, South Africa, Switzerland, Taiwan, Tajikistan, USA, Vietnam.

### Scientific Programme

Carrying out paramount advanced research in the field of computational mathematics and computational physics, directed to the creation of new mathematical methods, algorithms, and software for the numerical or symbolic-numerical solution of topics arising in experimental and theoretical studies, by using the newest computational tools, primarily the heterogeneous cluster HybriLIT. This subject area includes a wide spectrum of investigations underway at JINR in high energy physics, nuclear physics, condensed matter physics and nanotechnologies, biophysics, information technologies, etc., which demand the development of new mathematical methods and approaches for modeling physical processes, processing and analysis of experimental data, including the use of these studies in the NICA project, the neutrino programme and other strategic goals of the Institute. A distinctive feature of these investigations is the close cooperation of LIT with research groups from all the JINR laboratories and from Member State institutions.

#### Expected main results in 2017:

- The development of effective QCD-motivated models for describing properties of nuclear matter at NICA energies, computer simulations of the behavior of the critical points at the QCD phase diagram.  
Three-dimensional computer modeling of the magnetic field distribution in the superconducting magnets for NICA and SIS100 (FAIR).  
Development of methods of investigation of the dimesoatom formation in processes of multiple particle production at high energies including the coherent birth of long lived  $nP$  states of  $\pi^+\pi^-$  atoms.  
Study within the microscopic optical potential model of the mechanisms of various nuclear processes, including pre-equilibrium processes in the reactions  $(p,\alpha)^{59}Co$  at energies from 65 to 160 MeV, disintegration processes in the interactions of boron isotopes and other exotic nuclei with protons and nuclei, the inelastic interaction of pions with nuclei at  $(33)$ -resonance energies.  
Development and maintenance of the primary data processing program SAS for the YuMO spectrometer at IBR-2. Implementation of data processing for the position sensitive detectors for isotopically scattering samples.  
Numerical analysis of properties of Bose condensates with nonlocal interaction potentials.  
Development of methods for numerical investigations of structures and bifurcation regimes in non-linear models of condensed matter physics.  
Mathematical modeling of beam dynamics for multipurpose isochronous cyclotrons.  
Development of methodology, algorithms and programs for digital processing of arbitrary plane curves with the aim to obtain their analytic forms.  
Bayesian automatic adaptive quadrature with scale dependent quadrature sums.  
Numerical solution of boundary value problems for the nonlinear Boltzmann-Poisson equations describing the interaction of protein macromolecules with the solvent.

Study of the applicability of fractal analysis methods for processing and systematization of the results of molecular dynamics simulations of the interaction of nanocluster beams with thin metal films.

Development of algorithms and software for predictive analysis and forecasting parameters of the IBR-2M reactor (fluctuations of the pulse energies, the flow of liquid sodium through the core, etc.).

- Development and support of Glauber Monte Carlo program as well as adaptation of Geant4 FTF model for NICA/MPD and CBM experiments.

Development of the dataflow control system in the experiments of the NICA project.

Processing and analysis of data collected at the NUCLON experiment.

Software support of ATLAS experiment (maintenance of the TDAQ components previously developed in LIT; new developments: network monitoring dashboard, online TDAQ Log Manager)

Software development for the GEM tracking detector entering the detector complex of the BM@N experiment (development of algorithms and software for the simulation of realistic data with the microstrip GEM camera; development and software implementation of algorithms for the reconstruction of the spatial coordinates of the points of interaction of the charged particles with the registering elements of the GEM detector; software implementation of GEM detector models for the foreseen configurations planned in the upcoming sessions of the BM@N experiment).

BM@N: Event reconstruction with 2016-2017 Nuclotron data; development of algorithms and programs for the particle trajectories recognition in the MPD setup.

CMS: CSC local reconstruction improvement with high luminosity LHC data.

Development of VMRIA package for the automatic analysis of large spectra collected in experiments carried out on HRFD at IBR-2.

Development of methods for automatic analysis of gamma spectra and software for automatic calibration of low statistics gamma spectra.

Development and adaptation of methods of data analysis to the conditions of small statistics and incomplete observations (estimated half-lives).

Development of methods based on the generalized separate form factor model, for the analysis of experimental data of small angle neutron and synchrotron radiation on vesicular polydisperse nano-systems.

Adaptation of the algorithm L1 – recognition and track reconstruction of charged particles, based on the application of cellular automata, for the detector MVD of the CBM experiment.

Development of a system of testing and quality evaluation for the time-oriented clustering algorithms and the hit search and its software implementation for the STS detector of the CBM experiment.

Visualization of the procedure of the track reconstruction of charged particles in the MUCH detector of the CBM experiment.

Development of selection criteria of the rare decays  $J/\psi \rightarrow \mu^+\mu^-$  using data from within the coordinate planes of the MUCH detector. Development of algorithms for recognition and reconstruction of rare decays of light vector mesons,  $J/\psi \rightarrow e^+e^-$ , recorded in the CBM experiment.

Vectorization and parallelization of the trajectory reconstruction algorithm of the charged muons registered by the MUCH detector.

Analysis of RICH detector data obtained in a test experiment at CERN. Software development for simulation and reconstruction of events recorded by the RICH detector. Optimization of the geometry of the RICH detector. Software development of the data acquisition system (DAQ) and of the software interface between the DAQ and CBMRoot for the RICH detector online analysis.

Development, optimization and testing of algorithms for the event processing system FLES on multicore servers at LIT. Inclusion of the 4D-reconstruction time slices in CBMROOT. Study of the problem of possible event cleavage in the border areas between neighboring time slices.

Development of a database system for the CBM experiment: 1) implementation of component-wise database adapted to the features of the various detectors of the CBM facility; 2) implementation of the structure of the geometric database.

Development of methods and algorithms for massive calculations of electrostatic potentials of molecules of DNA, RNA and protein factors, as well as maps of the surface of these biopolymers. Calculation at the HybriLIT cluster of electrostatic potentials and surface maps of biopolymer molecules enabling solutions of biomolecular recognition problems.

Generation of random rough surfaces to simulate features of diffraction patterns at neutron reflection from the surface of nanostructured objects.

- Development and maintenance of the information-computing environment of the heterogeneous cluster HybriLIT.

Development of algorithms for numerical investigation of multi-dimensional models of evolutionary equations modeling physical processes in different materials under irradiation with heavy ions and pulsed beams, Josephson barriers in high-temperature superconductors. Their code implementation for computations on HybriLIT.

Development of efficient algorithms for the solution of molecular dynamics equations on hybrid computing infrastructures.

Development of methods and MPI packages for the computation of multiple integrals for the study of processes of ionization and photoionization of the He atom, polyatomic molecules, and their ions.

Development and implementation of new parallel algorithms into the MCTDHB software complex and their adaptation to the new KNL architecture of the Intel Xeon Phi.

Development and maintenance of the Fitter program, including implementation of its parallel version.

HybriLIT devoted optimization of selected programs of the ROOT software package, in particular, improvement, using technologies of parallel computing, of the software implementation of the filling algorithms of the special data structure Tree.

Elaboration of effective algorithms for solving elliptic nonlinear hp-adapted finite-element systems of equations and their program implementation on heterogeneous architectures.

Adaptation of the multibranch solutions of the Tolman-Oppenheimer-Volkov system of equations to hybrid computing architectures.

Set up, testing and validation of different modules of Comsol Multiphysics® package and of the "CATIA-GDML Geometry Builder" complex on the cluster HybriLIT and their adaptation for solving engineering-physical problems in JINR laboratories.

- Development and investigation of a new model of quantum networks with memory function.

Description of separable and entangled X-states of two-qubit systems.

Calculation of relativistic corrections in the description of dynamics of spin particles in strong laser fields (for project ELI-NP, Romania).

Derivation, based on unitary representations of finite groups, of combinatorial algorithms and algorithms of statistical modelling of quantum systems.

Creation of a symbolic-numerical package implementing the finite element method with associated Hermite polynomials for the solution of equations describing the dynamics of low-dimensional few-particle quantum systems. Adaptation of the developed algorithms and codes to hybrid architectures.

Algorithmic construction of difference schemes inheriting the basic algebraic properties of the initial differential equations.

Computation of the renormalization constants for the two-loop propagator of quark mixtures.

Design and implementation of algorithms for computation of rotational-vibrational basis functions in the space of parameters describing quadrupole and octupole deformation of spherical nuclei.

Implementation in Lucid Common Lisp of the computer algebra system Reduce with a convenient user interface toward libraries of numerical programs.

**List of activities:**

<b>Activity or experiment</b>	<b>Leaders</b>
<b>Laboratory or other</b>	<b>Main researchers</b>
<b>Division of JINR</b>	
<b>1. Mathematical and computation methods for simulation of complex physical systems</b>	<b>Gh. Adam</b> <b>I.V. Puzynin</b>
LIT	S. Adam, P.G. Akishin, I.V. Amirkhanov, E.A. Ayrjan, A.S. Ayriyan, I.V. Barashenkov, M.V. Bashashin, I.L. Bogolubsky, N.D. Dikoussar, H. Grigorian, Yu.L. Kalinovsky, T.V. Karamysheva, D.S. Kulyabov, K.V. Lukyanov, D.V.A. Luu, A. Machavariani, N.V. Makhaldiani, T.I. Mikhailova, G.J. Musulmanbekov, E.G. Nikonov, G.A. Ososkov, D.I. Podgainy, R.V. Polyakova, T.P. Puzynina, V.N. Robuk, B. Saha, N.Yu. Shirikova, A.G. Soloviev, T.M. Solovieva, Yu.B. Starchenko, O.I. Streltsova, A.V. Volokhova, O.O. Voskresenskaya, A. Wojczehowski, R.M. Yamaleev, E.P. Yukalova, E.V. Zemlyanaya
VBLHEP	E.E. Donets, S. Gevorkyan, M.N. Kapishin, A.O. Kechechyan, H.G. Khodzhbagiyani, V.A. Nikitin, O.V. Rogachevski, W. Scheinast
BLTP	A.V. Friesen, M. Hnatic, E.-M. Ilgenfritz, R.V. Jolos, V.K. Lukyanov, V.D. Toneev, S.N. Vinitzky, V.V. Voronov, V.I. Yukalov
FLNR	A.G. Artukh, Yu.K. Kochnev, S.M. Lukyanov, Yu.E. Penionzhkevich, R.A. Rymzhanov, Yu.M. Sereda, V.A. Skuratov
FLNP	A.V. Belushkin, N. Korepenova, S.A. Manoshin, A.I. Kuklin, A.I. Ivankov, Yu.N. Pepelyshev, D.V. Soloviev
DLNP	L.G. Afanasiev, G.A. Karamysheva, I.N. Kiyani
<b>2. Software complexes and mathematical methods for processing and analysis of experimental data</b>	<b>P.V. Zrelov</b> <b>V.V. Ivanov</b>
LIT	T.O. Ablyazimov, E.P. Akishina, V.P. Akishina, E.I. Aleksandrov, I.N. Aleksandrov, D.A. Baranov, S. Belogurov, O.Yu. Derenovskaya, A.A. Kazakov, A.I. Kazymov, P.I. Kisel, B.F. Kostenko, G.E. Kozlov, L.Yu. Kruglova, I.N. Kukhtina, A.A. Lebedev, T.I. Mikhailova, M.A. Mineev, G.A. Ososkov, E.V. Ovcharenko, V.I. Palichik, V.S. Rikhvitsky, V.N. Shigaev, N.Yu. Shirikova, L.A. Siurakhshina, S.K. Slepnev, A.N. Sosnin, V.A. Stepanenko, V.V. Uzhinsky, N.N. Voitishin, A.V. Yakovlev, E.V. Zemlyanaya, E.I. Zhabitskaya, V.B. Zlokazov
VBLHEP	A.S. Galoyan, K.V. Gertsenberger, M.N. Kapishin, V.P. Ladygin, V. Lenivenko, A.I. Malakhov, S.A. Movchan, O.V. Rogachevsky, M.G. Sapozhnikov, N.D. Topilin



FLNR	A.G. Artukh, A.S. Fomichev, Yu.E. Penionzhkevich, Yu.M. Sereda, Yu.G. Sobolev, Yu.S. Tsyganov, V.K. Utenkov
FLNP	A.M. Balagurov, I.A. Bobrikov, M.A. Kiselev, D.P. Kozlenko, M.V. Frontasyeva
DLNP	G.D. Alekseev, I.V. Bednyakov, V.A. Bednyakov, A.G. Olshevsky, D.B. Pontecorvo, A.S. Zhemchugov
UC	S. Pakuliak
<b>3. Numerical methods, algorithms and software computationally adapted to multicore and hybrid architectures</b>	<b>Gh. Adam</b> <b>P.V. Zrelov</b> <b>O.I. Streltsova</b>
LIT	E.I. Aleksandrov, I.V. Amirkhanov, A.S. Ayriyan, E.A. Ayrjan, M.V. Bashashin, D.V. Belyakov, A.M. Chervyakov, O. Chuluunbaatar, M. Kirakosyan, M.A. Matveev, E.V. Ovcharenko, D.V. Podgainy, T.P. Puzynina, A.A. Sapozhnikov, T.F. Sapozhnikova, N.R. Sarkar, I. Sarkhadov, S.I. Serdyukova, Z.A. Sharipov, A.G. Soloviev, T.M. Solovieva, Sh. Torosyan, Z.K. Tukhliev, A.V. Volokhova, O.I. Yuldashev, M.B. Yuldasheva, E.V. Zemlyanaya, E.I. Zhabitskaya, M.I. Zuev
LIT-MICC	V.V. Korenkov, V.V. Mitsyn, T.A. Strizh
FLNR	P.Yu. Apel, V.A. Skuratov
BLTP	D.B. Blashke, A.A. Bulychev, Yu.V. Popov, Yu.M. Shukrinov
<b>4. Methods, algorithms and software of computer algebra</b>	<b>V.P. Gerdt</b>
LIT	V. Abgaryan, A.A. Bogolubskaya, O. Chuluunbaatar, S.A. Evlakhov, A.A. Gusev, A.M. Khvedelidze, V.V. Kornyak, A.M. Raportirenko, I.A. Rogozhin, O.V. Tarasov, A.G. Torosyan, D.A. Yanovich, E.P. Yukalova
BLTP	A.V. Czhizhov, P. Fiziev, A.I. Titov, S.I. Vinitisky, V.I. Yukalov
FLNR	B.N. Gikal

### Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	YSU IIAP NAS RA RAU Foundation ANSL
Australia	Sydney	Univ.
Azerbaijan	Baku	IP ANAS

Belarus	Minsk	IM NASB
	Gomel	GSTU
Belgium	Brussels	ULB
	Liege	ULg
Brazil	Sao Carlos, SP	IFSC USP
Bulgaria	Sofia	IMI BAS
		INRNE BAS
		SU
	Plovdiv	PU
Canada	Toronto	IBM Lab
CERN	Geneva	CERN
China	Hangzhou	ZJU
Czech Republic	Prague	CTU
France	Nancy	UL
	Nantes	SUBATECH
Georgia	Tbilisi	UG
		TSU
		GTU
Germany	Bonn	UniBonn
	Darmstadt	GSI
	Dresden	IFW
	Frankfurt/Main	Univ.
	Giessen	JLU
	Hamburg	Univ.
	Heidelberg	Univ.
	Jena	Univ.
	Wuppertal	UW
	Freiberg	TUBAF
	Kassel	Uni Kassel
	Marburg	Univ.
	Munich	LMU
Greece	Thessaloniki	AUTH
India	Calcutta	JU
Italy	Turin	INFN
	Bari	UniBa
Japan	Osaka	Kansai Univ.
Kazakhstan	Almaty	INP
Moldova	Chişinău	IAP ASM
Mongolia	Ulaanbaatar	NUM
		MUST
Poland	Krakow	NINP PAS
	Lublin	UMCS
	Otwock-Swierk	NCBJ
	Warsaw	WUT
	Wroclaw	UW

Portugal	Lisbon	UL
Romania	Bucharest	IFA
		IFIN-HH
		ISS
		UB
	Cluj-Napoca	INCDTIM
Russia	Moscow	IPMech RAS
		ITEP
		NNRU "MEPhI"
		KIAM RAS
		MSU
		PFUR
		SINP MSU
		RCC MSU
		GPI RAS
		NRC KI
		ICS RAS
	Dubna	Dubna Univ.
	Gatchina	PNPI
	Protvino	IHEP
	Puschino	IMPB RAS
		ITEB RAS
		IPR RAS
	Saratov	SSU
	St. Petersburg	FIP
		NIEFA
	Tomsk	TSU
Slovakia	Košice	IEP SAS
		TUKE
		PJSU
	Prešov	PU
	Banska Bistrica	UMB
South Africa	Cape Town	UCT
	Pretoria	UP
	Stellenbosch	SU
Switzerland	Zurich	ETH
Taiwan	Taipei	AS
Tajikistan	Dushanbe	TNU
		PHTI ASRT
	Khujent	KSU
USA	Argonne, IL	ANL
	Stanford, CA	SU
Vietnam	Hanoi	VNU

**Analytical and Methodological Work to Assess the Prospects  
of Scientific Research and Cooperation in the Main Directions  
of JINR's Development.  
Organization of International Cooperation**

**Leader:** A.S. Sorin

**Participating Countries and International Organizations:**

Member States of JINR, non-Member States participating in JINR activities on the basis of bilateral agreements, and international organizations.

**Scientific Programme**

Preparation by the JINR Science Organization Department of analytical materials on the prospects of scientific research. Preparation of research plans. Preparation of scientific-organizational and methodological materials concerning special-purpose financing of research areas, themes and projects. Application of data base systems for the analysis of results of theoretical and experimental research activities. Organization of international cooperation with the Member States of JINR, non-Member States participating in JINR activities on the basis of bilateral agreements, and with scientific research institutions with which JINR has collaboration agreements.

**Expected main results in 2017:**

- Analysis of the results of JINR activities in the main directions of research. Preparation for publication of the JINR Topical Plan for Research and International Cooperation for 2018.
- Information and technical preparation of the JINR Web site. Support of the electronic system of protocols for scientific and technical collaboration.
- Preparation for publication of JINR Annual Reports Preparation of materials for the INIS system.
- Maintenance of interaction with representatives of the JINR Member States and non-Member States participating in JINR activities on the basis of bilateral agreements in the field of scientific research. Organization and holding of meetings of the Cooperation Committees. Maintenance of JINR's interaction with international organizations.

**List of activities:**

<b>Activity or experiment</b>	<b>Leaders</b>
<b>Laboratory or other</b>	<b>Main researchers</b>
<b>Division of JINR</b>	
1. <b>Preparation for publication of the JINR Topical Plan for Research and International Cooperation for 2018</b>	<b>A.S. Sorin</b>
SOD	N.A. Boklagova, L.K. Ivanova, N.I. Sissakian
2. <b>Maintenance of the JINR site</b>	<b>A.S. Sorin</b>
SOD	N.A. Boklagova, L.K. Ivanova, O.K. Kronshtadtov, K.P. Moisenz, A.G. Nanev, N.I. Sissakian
SID	B.M. Starchenko

Editorial office, weekly newspaper  
“Dubna: Science, Cooperation,  
Progress”

LIT

**3. International cooperation**

ICD

E.M. Molchanov

K.V. Lukyanov, A.V. Prikhodko

**D.V. Kamanin**

A.A. Kotova, A.A. Sushevich



Educational  
Programme  
(06)

## Organization, Support and Development of the JINR Educational Programme

**Leaders:**

V.A. Matveev  
S.Z. Pakuliak

**Participating Countries and International Organizations:**

Armenia, Azerbaijan, Belarus, Bulgaria, CERN, Czech Republic, Egypt, Kazakhstan, Moldova, Poland, Romania, Russia, Slovakia, South Africa, Ukraine, USA.

**Scientific Programme**

Support and development of the JINR Educational Programme in general (training of physicists and engineers in JINR fields of research and in the interest of the Member States). Further professional development, training and retraining of JINR engineering and technical staff. Promotion of physics research and of the Institute activities among the youth of the Member States including high-school students, university students, and school teachers.

**Expected main results in 2017:**

- Support and maintenance of the educational process at JINR-based departments of Russian universities. Preparation and publication – as tutorials – of lectures given to the students and postgraduates at the UC. Support of the system of assigning young researchers to JINR laboratories for preparation of PhD theses without mastering the academic programmes of PhD courses.
- Organization and running of Summer Students Practices in JINR fields of research for students of higher-education institutions of JINR Member States. Participation in the organization and running of international schools on nuclear physics and particle physics for young scientists. Expansion of the research projects of the Summer Student Programme at JINR and the number of participants of this programme.
- Development of the training facilities for practice in the framework of a UC-based scientific and engineering group for the fulfilment of the educational programmes on training qualified specialists for the needs of JINR and other scientific centres of the Member States.
- Cooperation with international foundations in organizing student and postgraduate exchange between the UC and foreign research centres regulated by special agreements.
- Development of the computer infrastructure for organizing and conducting training programs for data analysis in high-energy physics experiments and for the design of modern physical facilities.
- Improvement of the training laboratory and inter-school elective courses for the organization of lecture courses and practical classes in physics for high-school students from Dubna and the Member States. Organization of scientific schools for teachers of physics from the Member States at CERN and JINR.
- Organization of real and virtual excursions to JINR and video-conferences for high-school students and teachers from the Member States. Development of the system of teaching Russian, English, French, and German to JINR staff.
- Development of training and educational programmes in nuclear and particle physics. Dissemination of information on the Virtual Laboratory of Nuclear Fission in the Member States.



## List of projects:

<b>Project</b>	<b>Leader</b>	<b>Priority (period of realization)</b>
1. Development of an open educational environment to support research priorities in materials science and structure of matter	Yu.A. Panebratsev	1 (2017 – 2019)

## List of activities:

<b>Activity or experiment</b>	<b>Leaders</b>
<b>Laboratory or other</b>	<b>Main researchers</b>
<b>Division of JINR</b>	
<b>Responsible person</b>	
<b>1. Organization of the Educational Process at JINR</b>	<b>V.A. Matveev</b> <b>S.Z. Pakuliak</b>
DLNP V.A. Bednyakov D.V. Naumov	G.A. Chelkov, A.G. Olshevskiy, V.V. Glagolev A.S. Zhemchugov
BLTP V.V. Voronov A.P. Isaev A.B. Arbuzov	D.I. Kazakov, A.V. Gladyshev, V.A. Osipov
FLNP V.N. Shvetsov E.V. Lychagin O.A. Culikov	B.N. Savenko, A.M. Balagurov, Yu.N. Kopach, A.V. Belushkin
VBLHEP R. Lednický V.D. Kekelidze	V.A. Nikitin, S.V. Shmatov, N.N. Agapov, S.S. Shimansky, N.I. Zimin
FLNR S.N. Dmitriev	A.V. Eremin V.I. Zagrebaev, A.G. Popeko, A.V. Karpov
LIT V.V. Korenkov	T.A. Strizh, V.P. Gerdt, D.V. Podgaynyi
LRB E.A. Krasavin	O.V. Belov, I.V. Koshlan
Directorate G.V. Trubnikov G.D. Shirkov	A.V. Dudarev, E.D. Uglov
SOICO D.V. Kamanin	W. Chmielowski, M.G. Loschilov
<b>2. Developing of modern educational projects</b>	<b>Y.A. Panebratsev</b>

## Collaboration

<b>Country or International Organization</b>	<b>City</b>	<b>Institute or Laboratory</b>
Armenia	Yerevan	YSU
Azerbaijan	Baku	IP ANAS

Belarus	Minsk	BSU INP BSU ISEI BSU ME RB
	Gomel	GSU GSTU
Bulgaria	Sofia	INRNE BAS SU
	Blagoevgrad	SWU
CERN	Geneva	CERN
Czech Republic	Prague	CU CTU
	Řež	NPI ASCR
Egypt	Cairo	ASRT
Kazakhstan	Almaty	KazNU
	Astana	ENU
	Ust-Kamenogorsk	EKSU
Moldova	Chişinău	ASM
Poland	Krakow	JU
	Lodz	UL
	Poznan	AMU
Romania	Bucharest	UB
Russia	Moscow	NNRU "MEPhI" SINP MSU MPEI
	Arkhangelsk	NSMU NArFU
	Belgorod	BelSU
	Voronezh	VSU
	Ivanovo	ISU
	Krasnodar	KSU
	Smolensk	SSU
	Tomsk	TPU
	Yakutsk	NEFU
	Dolgoprudny	MIPT
	Dubna	Dubna Univ. BSINP MSU
	Kostroma	KSU
	St. Petersburg	SPbSU
	Tver	TvSU
	Tula	TSU
Slovakia	Bratislava	CU
	Košice	PJSU
South Africa	Pretoria	DST
Ukraine	Kiev	BITP NASU

USA

Upton, NY

NUK  
BNL

## Alphabetic List of Collaborators

### Albania

#### *Tirana*

UT (University of Tirana |  
<http://www.unitir.edu.al/>), 126

### Argentina

#### *Bariloche*

CAB CNEA (Centro Atomico Bariliche  
National Atomic Energy Commission |  
<http://www.cab.cnea.gov.ar/>), 136

#### *Buenos Aires*

CNEA (National Atomic Energy Commission  
| <http://www.cnea.gov.ar/>), 142

### Armenia

#### *Garni*

GGO (Garni Geophysical Observatory), 82

#### *Yerevan*

ANSSP (Armenian National Survey for  
Seismic Protection | <http://www.nssp.gov.am/about-NSSP-eng.htm/>),  
82

CENS NAS RA (Center for  
Ecological-Noosphere Studies of the  
National Academy of Sciences of the  
Republic of Armenia |  
<http://www.cens.am/>), 126

Foundation ANSL (Alikhanian National  
Science Laboratory (Yerevan Physics  
Institute) Foundation |  
<http://www.yerphi.am/>), 11, 22, 39, 58, 64,  
91, 94, 97, 115, 177

IIAP NAS RA (Institute for Informatics and  
Automation Problems of the National  
Academy of Sciences of the Republic of  
Armenia), 171, 177

Inst. Physiology NAS RA (L.A.Orbeli  
Institute of Physiology of the National  
Academy of Sciences of the Republic of  
Armenia | <http://www.physiol.sci.am/>), 148

RAU (Russian-Armenian (Slavonic) University  
| <http://www.rau.am/>), 11, 17, 177

Shirak Technologies (<http://www.shte.am/>),  
82

YSU (Yerevan State University |  
<http://ysu.am/>), 27, 77, 91, 100, 115, 156,  
171, 177, 185

### Australia

#### *Crawley*

UWA (University of Western Australia |  
<http://www.uwa.edu.au/>), 27

#### *Melbourne*

Univ. (University of Melbourne |  
<http://unimelb.edu.au/>), 22, 126

#### *Sydney*

Univ. (University of Sydney |  
<http://sydney.edu.au/>), 22, 27, 100, 177

### Austria

#### *Innsbruck*

Univ. (University of Innsbruck |  
<http://www.uibk.ac.at/>), 17, 126

#### *Vienna*

HEPHY (Institute of High Energy Physics of  
the Austrian Academy of Sciences |  
<http://www.hephy.at/>), 58

IAEA (International Atomic Energy Agency |  
<http://www.iaea.org/>), 126

TU Wien (Vienna University of Technology |  
<http://www.tuwien.ac.at/>), 22, 27, 31

Univ. (University of Vienna |  
<http://www.univie.ac.at/>), 31

### Azerbaijan

#### *Baku*

AzTU (Azerbaijan Technical University |  
<http://aztu.edu.az/>), 136

BSU (Baku State University |  
<http://bsu.edu.az/>), 126

IP ANAS (Institute of Physics of the  
Azerbaijan National Academy of Sciences |  
<http://www.physics.gov.az/>), 11, 39, 77,  
136, 171, 177, 185

IRP ANAS (Institute of Radiation Problems  
of the Azerbaijan National Academy of  
Sciences | <http://www.irp.science.az/>), 94,  
142

NNRC (National Nuclear Research Center |  
<http://www.mntm.az/>), 142

#### *Ganja*

ASAU (Azerbaijan State Agricultural  
University | <http://adau.edu.az/>), 126

ATU (Azerbaijan Technological University |  
<http://www.aztun.edu.az/>), 126

### Belarus

#### *Gomel*

BNTU (Belarusian National Technical  
University, Branch of the Gomel |  
<http://www.bntu.by/>), 151

BelSUT (Belarusian State University of  
Transport | <http://www.belsut.gomel.by/>),  
11, 58

GEI (Gomel Engineering Institute of the Ministry for Emergency Situations of the Republic of Belarus | <http://gii.by/>), 151  
GSTU (Sukhoi State Technical University of Gomel | <http://www.gstu.by/>), 11, 39, 67, 78, 178, 186  
GSU (Francisk Skorina Gomel State University | <http://www.gsu.by/>), 11, 40, 58, 67, 78, 151, 186  
IRB NASB (Institute of Radiobiology of the National Academy of Sciences of Belarus | <http://irb.basnet.by/>), 156

### *Minsk*

BSTU (Belarusian State Technological University | <http://www.bstu.unibel.by/>), 22, 136, 146  
BSU (Belarusian State University | <http://www.bsu.by/>), 27, 119, 151, 186  
BSUIR (Belarusian State University of Informatics and Radioelectronics | <http://www.bsuir.by/>), 67, 78, 82, 148  
IAP NASB (State Scientific Institution “Institute of Applied Physics of the National Academy of Sciences of Belarus | <http://iaph.bas-net.by/>), 39, 67, 136, 142  
ICE MES RB (Institute for Command Engineers of the Ministry for Emergency Situations of the Republic of Belarus | <http://kii.gov.by/>), 22  
IM NASB (Institute of Mathematics of the National Academy of Sciences of Belarus | <http://im.bas-net.by/>), 178  
INP BSU (Research Institute for Nuclear Problems of the Belarusian State University | <http://www.inp.bsu.by/>), 11, 39, 42, 47, 58, 67, 77, 82, 86, 100, 119, 126, 136, 151, 171, 186  
IP NASB (B.I.Stepanov Institute of Physics of the National Academy of Sciences of Belarus | <http://ifanbel.basnet.by/>), 17, 22, 27, 39, 119, 156  
ISEI BSU (International Sakharov Environmental Institute of the Belarusian State University | <http://www.iseu.by/>), 186  
Institute of Physiology NASB (Institute of Physiology of the National Academy of Sciences of Belarus | <http://physiology.by/>), 149  
JIPNR-Sosny NASB (Joint Institute for Power and Nuclear Research - Sosny of the National Academy of Sciences of Belarus | <http://sosny.bas-net.by/>), 11, 22, 39, 77, 100, 171

ME RB (Ministry of Education of the Republic of Belarus | <http://edu.gov.by/>), 186  
PTI NASB (Physical Technical Institute of the National Academy of Sciences of Belarus | <http://www.phti.belhost.by/>), 78, 82  
RI PCP BSU (Research Institute for Physical Chemical Problems of the Belarusian State University | <http://www.fhp.bsu.by/>), 136  
RIAPP BSU (Research Institute of Applied Physical Problems of the Belarusian State University | <http://www.niipfp.bsu.by/>), 151  
SOL instruments (SOL instruments | <http://www.solinstruments.com/>), 148  
SPMRC NASB (Scientific-Practical Materials Research Centre of the National Academy of Sciences of Belarus | <http://www.physics.by/>), 78, 82, 136  
“Planar” (Planar Corporation | <http://www.planar.by/>), 78

## **Belgium**

### *Antwerp*

UA (University of Antwerp | <http://www.uantwerpen.be/>), 58

### *Brussels*

ULB (Free University of Brussels | <http://www.ulb.ac.be/>), 58, 110, 178  
VUB (Vrije University Brussels | <http://www.vub.ac.be/>), 17, 58

### *Geel*

IRMM (Institute for Reference Materials and Measurements of the Joint Research Centre of the European Commission | <http://irmm.jrc.ec.europa.eu/>), 126

### *Leuven*

KU Leuven (Catholic University of Leuven | <http://www.kuleuven.ac.be/>), 106, 110, 115

### *Liege*

ULg (University of Liège | <http://www.ulg.ac.be/>), 178

### *Louvain-la-Neuve*

IBA (Ion Beam Applications | <http://iba-worldwide.com/>), 106, 122  
UCL (Catholic University of Louvain | <http://www.uclouvain.be/>), 17, 22, 55, 58

### *Mons*

UMONS (University of Mons | <http://portail.umons.ac.be/>), 58

## **Brazil**

### *Brasilia, DF*

UnB (University of Brasilia | <http://www.unb.br/>), 22

### *Florianopolis, SC*

UFSC (Federal University of Santa Catarina | <http://ufsc.br/>), 17

### *Juiz de Fora, MG*

UFJF (Federal University of Juiz de Fora | <http://www.ufjf.br/>), 27

### *Natal, RN*

IIP UFRN (International Institute of Physics of the Federal University of Rio Grande do Norte | <http://www.iip.ufrn.br/>), 22

### *Niteroi, RJ*

UFF (Federal Fluminense University | <http://www.uff.br/>), 17

### *Rio de Janeiro, RJ*

CBPF (Brazilian Center for Physics Research | <http://portal.cbpf.br/>), 58

UERJ (Rio de Janeiro State University | <http://www.uerj.br/>), 58

UFRJ (Federal University of Rio de Janeiro | <http://www.ufrj.br/>), 58

### *Sao Carlos, SP*

IFSC USP (Institute of Physics of São Carlos of the University of São Paulo | <http://www.ifsc.usp.br/>), 178

### *Sao Jose dos Campos, SP*

ITA (Instituto Tecnológico de Aeronáutica | <http://www.ufcar.br/>), 17

### *Sao Paulo, SP*

UEP (Unidade de Ensino Profissionalizante da Santa Casa de São Paulo | <http://www.santacasasp.org.br/>), 17

USP (University of São Paulo | <http://www5.usp.br/>), 22, 27, 31

Unesp (São Paulo State University | <http://www.unesp.br/>), 58

## **Bulgaria**

### *Blagoevgrad*

SWU (South-West University “Neofit Rilski” | <http://www.swu.bg/>), 55, 78, 186

### *Plovdiv*

PU (Plovdiv University “Paisii Hilendarski” | <http://www.uni-plovdiv.bg/>), 55, 78, 115, 126, 151, 178

UFT (University of Food Technologies | <http://uft-plovdiv.bg/>), 126

### *Sofia*

ASCT Ltd (ASCI Ltd | <http://www.asci.bg/>), 136

IE BAS (Academician Emil Djakov Institute of Electronics of the Bulgarian Academy of Sciences | <http://ie-bas.dir.bg/>), 136, 156

IEES BAS (Institute of Electrochemistry and Energy Systems of the Bulgarian Academy of Sciences | <http://www.bas.bg/cleps/>), 136

IMI BAS (Institute of Mathematics and Informatics of the Bulgarian Academy of Sciences | <http://math.bas.bg/>), 178

IMS BAS (Institute of Metal Science, Equipment and Technologies “Acad. A.Balevsci” with Hydroaerodynamics Centre of the Bulgarian Academy of Sciences | <http://ims.bas.bg/>), 136

IMech BAS (Institute of Mechanics of the Bulgarian Academy of Sciences | <http://www.imbm.bas.bg/>), 22

INRNE BAS (Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences | <http://www.inrne.bas.bg/>), 11, 17, 22, 27, 31, 52, 58, 64, 78, 82, 91, 94, 101, 110, 115, 126, 136, 146, 156, 171, 178, 186

ISSP BAS (Georgi Nadjakov Institute of Solid State Physics of the Bulgarian Academy of Sciences | <http://www.issp.bas.bg/>), 22, 78, 136

LTD BAS (Laboratory for Technical Development of the Bulgarian Academy of Sciences | <http://www.pronto.phys.bas.bg/>), 78, 106

NBU (New Bulgarian University | <http://www.nbu.bg/>), 17

NCRRP (National Centre of Radiobiology and Radiation Protection | <http://ncrrp.org/>), 156

SU (Sofia University “St.Kliment Ohridski” | <http://www.uni-sofia.bg/>), 11, 22, 27, 31, 42, 55, 58, 64, 97, 119, 171, 178, 186

TU-Sofia (Technical University of Sofia | <http://www.tu-sofia.bg/>), 78

UCTM (University of Chemical Technology and Metallurgy | <http://www.uctm.edu/>), 86

## **Canada**

### *Edmonton*

U of A (University of Alberta; Theoretical Physics Institute; Avadh Bhatia Physics Laboratory | <http://www.ualberta.ca/>), 27, 31

### *Hamilton*

McMaster (McMaster University | <http://www.mcmaster.ca/>), 17

### *Kingston*

Queen’s (Queen’s University | <http://www.queensu.ca/>), 22

### *London*

Western (University of Western - Canada | <http://www.uwo.ca/>), 23

### *Montreal*

- Concordia (Concordia University Montreal | <http://www.concordia.ca/>), 22  
McGill (McGill University | <http://www.mcgill.ca/>), 11, 27  
UdeM (University of Montreal | <http://www.umontreal.ca/>), 11, 27, 31, 40

### *Quebec*

- UL (Laval University | <http://www2.ulaval.ca/>), 22

### *Saskatoon*

- U of S (University of Saskatchewan | <http://www.usask.ca/>), 17

### *Toronto*

- IBM Lab (IBM Toronto Software Lab | <http://www.ibm.com/>), 178  
U of T (University of Toronto | <http://www.utoronto.ca/>), 11

### *Vancouver*

- TRIUMF (Canada's National Laboratory for Particle and Nuclear Physics | <http://www.triumf.ca/>), 40, 119

## **Chile**

### *Valparaiso*

- UV (University of Valparaiso | <http://www.valpo.edu/>), 11

## **China**

### *Beijing*

- Beijing Fert Co (Beijing Fert Medical Instruments Technology Co., Ltd. | <http://www.china-fert.com/>), 151  
CIAE (China Institute of Atomic Energy | <http://www.ciae.ac.cn/>), 17, 91, 97  
IHEP CAS (Institute of High Energy Physics of the Chinese Academy of Sciences | <http://www.ihep.ac.cn/>), 37, 45, 58, 91, 126, 171  
ITP CAS (Institute of Theoretical Physics of the Chinese Academy of Sciences | <http://english.itp.cas.cn/>), 17  
PKU (Peking University | <http://www.pku.edu.cn/>), 17, 58, 151  
"Tsinghua" (Tsinghua University | <http://www.tsinghua.edu.cn/>), 78

### *Hangzhou*

- ZJU (Zhejiang University | <http://www.zju.edu.cn/>), 178

### *Hefei*

- IPP CAS (Institute of Plasma Physics of the Chinese Academy of Sciences | <http://english.ipp.cas.cn/>), 122  
USTC (University of Science and Technology of China | <http://www.ustc.edu.cn/>), 58

### *Lanzhou*

- IMP CAS (Institute of Modern Physics of the Chinese Academy of Sciences | <http://www.impcas.cn/>), 11, 106, 110

### *Wuhan*

- CCNU (Central China Normal University; Institute of Particle Physics | <http://www.ccnu.edu.cn/>), 91, 97  
WIPM CAS (Wuhan Institute of Physics and Mathematics of the Chinese Academy of Sciences | <http://english.wipm.cas.cn/>), 11

## **Croatia**

### *Split*

- Univ. (University of Split | <http://www.unist.hr/>), 58

### *Zagreb*

- Oikon IAE (Oikon Ltd. Institute for Applied Ecology | <http://www.oikon.hr/>), 126  
RBI (Rudjer Boskovic Institute | <http://www.irb.hr/>), 97, 119, 126

## **Cuba**

### *Havana*

- CEADEN (Centre of Technological Applications and Nuclear Development | <http://www.ceaden.cu/>), 151  
UCI (University of Computer Sciences | <http://www.uci.cu/>), 171

## **Cyprus**

### *Nicosia*

- UCY (University of Cyprus | <http://www.ucy.ac.cy/>), 58

## **Czech Republic**

### *Brno*

- BUT (Brno University of Technology | <http://www.vutbr.cz/>), 101, 106, 151  
IBP ASCR (Institute of Biophysics of the Academy of Sciences of the Czech Republic, v.v.i. | <http://www.ibp.cz/>), 156  
ISI ASCR (Institute of Scientific Instruments of the Academy of Sciences of the Czech Republic, v.v.i. | <http://www.isibrno.cz/>), 86

### *Liberec*

- TUL (Technical University of Liberec | <http://www.tul.cz/>), 78, 86

### *Opava*

- SIU (Silesian University of Opava | <http://www.slu.cz/>), 27

### *Ostrava*

- VSb-TUO (Technical University of Ostrava | <http://www.vsb.cz/>), 126

## *Plzen*

“Skoda” (Škoda Factory |  
<http://www.skoda.cz/>), 142

## *Prague*

CEI (Czech Environmental Institute |  
<http://www.ceu.cz/>), 126

CTU (Czech Technical University in Prague |  
<http://www.cvut.cz/>), 11, 27, 31, 67, 82, 86,  
101, 106, 110, 115, 126, 136, 156, 164, 178,  
186

CU (Charles University in Prague |  
<http://www.cuni.cz/>), 11, 17, 27, 40, 45, 47,  
49, 55, 58, 64, 78, 86, 95, 106, 119, 151, 186

IG ASCR (Institute of Geology of the  
Academy of Sciences of the Czech Republic,  
v.v.i. | <http://www.gli.cas.cz/>), 136

IMC ASCR (Institute of Macromolecular  
Chemistry of the Academy of Sciences of  
the Czech Republic, v.v.i. |  
<http://www.imc.cas.cz/>), 91, 136

IP ASCR (Institute of Physics of the Academy  
of Sciences of the Czech Republic, v.v.i. |  
<http://www.fzu.cz/>), 11, 31, 97, 136, 171

NORM Free s.r.o. (NORM Free s.r.o.), 151

PTC (Proton Therapy Center ‘zech s.r.o |  
<http://www.ptc.cz/>), 162

VP (Vacuum PRAGUE |  
<http://www.vakuum.cz/>), 106, 110

## *Vitkovice*

VHM (Vitkovice Heavy Machinery a.s. |  
<http://www.brtnik5.vitkovice.cz/>), 78

## *Řež*

NPI ASCR (Nuclear Physics Institute of the  
Academy of Sciences of the Czech Republic,  
v.v.i. | <http://www.ujf.cas.cz/>), 11, 17, 23,  
27, 31, 52, 67, 86, 91, 95, 106, 111, 115, 119,  
136, 146, 152, 156, 186

UJV (“ÚJV Řež, a.s.” | <http://www.ujv.cz/>),  
67, 95, 97, 101, 142, 156, 162

## *Štěnovice*

STREICHER (STREICHER |  
<http://www.streicher.cz/>), 106

## **Denmark**

### *Copenhagen*

NBI (Niles Bohr Institute of the University of  
Copenhagen | <http://www.nbi.ku.dk/>), 97

## **Egypt**

### *Al-Minufya*

MU (Menoufia University | [http://mu  
menofia.edu.eg/](http://mu<br/>menofia.edu.eg/)), 106, 111

### *Alexandria*

Univ. (Alexandria University |  
<http://www.alexu.edu.eg/>), 126

## *Cairo*

ASRT (Academy of Scientific Research and  
Technology | <http://www.asrt.sci.eg/>), 186

CU (Cairo University | <http://cu.edu.eg/>), 136

EAEA (Egyptian Atomic Energy Authority |  
<http://www.eaea.org.eg/>), 17, 126, 136

ECTP (Egyptian Center for Theoretical  
Physics | <http://www.mti.edu.eg/ECTP/>),  
78

TIMS (Tabbin Institute for Metallurgical  
Studies | <http://www.tins.gov.eg/>), 152

## *Giza*

CU (Cairo University |  
<http://cuportal.cu.edu.eg/>), 17, 106, 111,  
156, 171

## *Shibin al Kawm*

MU (Menoufia University |  
<http://mu.menoufia.edu.eg/>), 127

## **Estonia**

### *Tallinn*

NICPB (National Institute of Chemical  
Physics and Biophysics |  
<http://www.kbfi.ee/>), 58

## **Finland**

### *Helsinki*

HIP (Helsinki Institute of Physics |  
<http://www.hip.fi/>), 58

UH (University of Helsinki |  
<http://www.helsinki.fi/university/>), 11, 58

### *Jyväskylä*

UJ (University of Jyväskylä |  
<http://www.jyu.fi/>), 58, 111, 115, 127

### *Oulu*

UO (University of Oulu; Microelectronics  
Instrumentation Laboratory |  
<http://www oulu.fi/>), 58, 127

### *Tampere*

TUT (Tampere University of Technology;  
Digital and Computer Systems Laboratory |  
<http://www.tut.fi/>), 58

## **France**

### *Annecy-le-Vieux*

LAPP (Laboratory of Annecy-la-Vieux for  
Particles Physics of the National Institute  
for Nuclear Physics and Particles Physics of  
the National Centre for Scientific Research |  
<http://lappweb.in2p3.fr/>), 27, 31, 58

LAPTh (Laboratory of Theoretical Physics of  
Annecy-la-Vieux of the National Institute  
for Nuclear Physics and Particles Physics of  
the National Centre for Scientific Research |  
<http://lappweb.in2p3.fr/lapth-2005/>), 23, 28



### *Bordeaux*

CENBG (Centre of Nuclear Studies of Bordeaux-Gradignan | <http://www.cenbg.in2p3.fr/>), 115  
UB (University of Bordeaux | <http://www.univ-bordeaux.fr/>), 17

### *Cadarache*

CC CEA (Centre de Recherche du Commissariat à l'Énergie Atomique et aux Énergies Alternatives Cadarache | <http://www-cadarache.cea.fr/>), 127

### *Caen*

GANIL (Grand National Heavy Ion Accelerator | <http://www.ganil-spiral2.eu/>), 17, 106, 111  
UNICAEN (University of Caen Normandy | <http://www.unicaen.fr/>), 115

### *Clermont-Ferrand*

LPC (Corpuscular Physics Laboratory Clermont-Ferrand of the Blaise Pascal University | <http://clrwww.in2p3.fr/>), 40, 97

### *Dijon*

UB (University of Bourgundy | <http://www.u-bourgogne.fr/>), 28, 31

### *Grenoble*

IBS (Institute of Structural Biology | <http://www.ibs.fr/>), 136, 149  
ILL (Institute Laue-Langevin | <http://www.ill.eu/>), 127, 146  
LPSC (Laboratoire de Physique Subatomique et de Cosmologie | <http://lpscwww.in2p3.fr/>), 127

### *Lyon*

ENS Lyon (Ecole Normale Supérieure de Lyon; Physics Laboratory | <http://www.ens-lyon.eu/>), 28, 31  
IPNL (Institute of Nuclear Physics of Lyon | <http://www.ipnl.in2p3.fr/>), 58  
UCBL (Claude Bernard University Lyon 1 | <http://www.univ-lyon1.fr/>), 11, 97

### *Marseille*

CPPM (Centre de Physique des Particules de Marseille | <http://marwww.in2p3.fr/>), 171  
CPT (Centre of Theoretical Physics | <http://www.cpt.univ-mrs.fr/>), 23, 28, 31  
UPC (University Paul Cézanne - Aix-Marseille III | <http://www.univ-cezanne.fr/>), 23

### *Metz*

UPV-M (Paul-Verlaine University of Metz | <http://www.univ-metz.fr/>), 11

### *Montpellier*

UM2 (University of Montpellier 2 | <http://www.univ-montp2.fr/>), 11

### *Nancy*

UL (University of Lorraine | <http://www.univ-lorraine.fr/>), 178

### *Nantes*

SUBATECH (Subatomic Physics Laboratory and Associated Technologies; UMR/EMN/IN2P3/CNRS/University of Nantes | <http://www-subatech.in2p3.fr/>), 28, 31, 78, 95, 97, 178

### *Nice*

UN (University Nice Sophia Antipolis | <http://unice.fr/>), 23

### *Orsay*

CSNSM (Center for Nuclear and Mass Spectrometry- IN2P3/CNRS | <http://www-csnm.in2p3.fr/>), 17, 111, 115  
IPN Orsay (Institute of Nuclear Physics Orsay - IN2P3/CNRS | <http://ipnweb.in2p3.fr/>), 17, 86, 91, 97, 111  
LAL (Linear Accelerator Laboratory of the University of Paris-Sid 11 - IN2P3/CNRS | <http://www.lal.in2p3.fr/>), 40, 115

### *Palaiseau*

Polytech (Ecole Polytechnique | <http://www.polytechnique.fr/>), 28

### *Paris*

ENS (École Normale Supérieure Paris | <http://www.ens.fr/>), 28, 31  
LPTHE (Laboratory of Theoretical Physics and High Energy of the Pierre et Marie Curie - IN2P3/CNRS | <http://parthe.lpthe.jussieu.fr/>), 28, 31  
LUTH (Laboratory Universe and Theories, Observatory of Paris | <http://www.luth.obspm.fr/>), 28  
UPMC (Pierre et Marie Curie University Henri Poincaré Institute Paris 6 | <http://www.upmc.fr/>), 11, 23, 31

### *Saclay*

IRFU (Institute of Research into the Fundamental Laws of the Universe | <http://irfu.cea.fr/>), 11, 58, 64, 86, 97, 119  
LLB (Léon Brillouin Laboratory CEA-CNRS | <http://www-llb.cea.fr/>), 127, 136, 146  
SPhN CEA DAPNIA (Nuclear Physics Division of the Commissariat for Atomic Energy | <http://irtu.cea.fr/Sphn>), 11, 111

### *Strasbourg*

CRN (Centre of Nuclear Research - IN2P3/CNRS | <http://ireswww.in2p3.fr/>), 45, 97, 111  
IPHC (Hubert Curien Multidisciplinary Institute of the University of Strasbourg - IN2P3/CNRS | <http://www.iphc.cnrs.fr/>), 58, 111, 127

## *Valenciennes*

UVHC (University of Valenciennes and Hainaut-Combr sis | <http://www.univ-valenciennes.fr/>), 23, 28, 31

## *Vannes*

SigmaPhi (Company SigmaPhi Accelerator Technologies | <http://www.sigmaphi.fr/>), 106

## **Georgia**

### *Tbilisi*

AIP TSU (Elevter Andronikashvili Institute of Physics of the Ivane Javakishvili Tbilisi State University | <http://aipphysics.ge/>), 58, 78, 127

GRENA (Georgian Research and Educational Networking Association | <http://grena.ge/>), 171

GTU (Georgia Tecnical University | <http://www.gtu.ge/>), 78, 171, 178

HEPI-TSU (High Energy Physics Institute of Ivane Javakishvili Tbilisi State University | <http://www.hepi.edu.ge/>), 40, 42, 58, 83, 119

RMI TSU (Andrea Razmadze Mathematical Institute of the Ivane Javakishvili Tbilisi State University | <http://www.rmi.ge/>), 11  
TSU (Ivane Javakishvili Tbilisi State University | <http://www.tsu.ge/>), 127, 171, 178

UG (University of Georgia | <http://www.ug.edu.ge/>), 178

## **Germany**

### *Aachen*

RWTH (Aachen University | <http://www.rwth-aachen.de/>), 11, 45, 58, 119

### *Bayreuth*

Univ. (University of Bayreuth | <http://www.uni-bayreuth.de/>), 136

### *Berlin*

BAM (Federal Institute for Materials Reseach and Testing | <http://www.bam.de/>), 136

FU Berlin (Free University of Berlin | <http://www.fu-berlin.de/>), 11, 28

HUB (Humboldt University of Berlin | <http://www.hu-berlin.de/>), 11, 28, 58

HZB (Helmholtz Centre Berlin of the Helmholtz Association | <http://www.helmholtz-berlin.de/>), 111, 136, 146

MBI (Max-Born-Institute in Berlin for Nonlinear Optics and Short Pulse

Spectroscopy im Forschungsverbund Berlin e.V. | <http://www.mbi-berlin.de/>), 28

### *Bielefeld*

Univ. (University of Bielefeld | <http://www.uni-bielefeld.de/>), 11, 28, 64

### *Bochum*

RUB (Ruhr University of Bochum | <http://www.ruhr-uni-bochum.de/>), 11, 64, 86, 136

### *Bonn*

UniBonn (University of Bonn | <http://www3.uni-bonn.de/>), 11, 17, 23, 28, 31, 64, 178

### *Braunschweig*

TU (Technical University Carolo-Wilhelmina at Braunschweig | <http://www.tu-braunschweig.de/>), 23

### *Bremen*

Univ. (University of Bremen | <http://www.uni-bremen.de/>), 23

### *Cologne*

Univ. (University of Cologne | <http://www.uni-koeln.de/>), 17, 119

### *Darmstadt*

GSI (Helmholtz-Centre for Heavy Ion Research of the Helmholtz Association | <http://www.gsi.de/>), 17, 23, 47, 52, 78, 82, 91, 97, 106, 111, 152, 171, 178

IKP (Institute of Nuclear Physics of the Darmstadt University of Technology | <http://www.physik.tu-darmstadt.de/>), 17

TU Darmstadt (Technical University of Darmstadt | <http://www.tu-darmstadt.de/>), 17, 91, 101, 127, 136

### *Dortmund*

TU Dortmund (Technical University of Dortmund | <http://www.uni-dortmund.de/>), 11, 23, 28, 136

### *Dresden*

HZDR (Dresden-Rossendorf Helmholtz Centre | <http://www.hzdr.de/>), 17, 52, 91, 119, 127

IFW (Leibniz Institute for Solid State and Materials Research Dresden | <http://www.ifw-dresden.de/>), 23, 178

ILK (Institute of Air Handling and Refrigeration | <http://www.ilkdresden.de/>), 78

MPI PkS (Max Planck Institute for the Physics of Complex Systems | <http://www.mpi-pks-dresden.mpg.de/>), 23

TU Dresden (Technical University of Dresden | <http://tu-dresden.de/>), 23, 86, 137

### *Duisburg*

UDE (University of Duisburg-Essen | <http://www.uni-due.de/>), 23

### *Erlangen*

FAU (Friedrich Alexander University of Erlangen-Nuremberg | <http://www.uni-erlangen.org/>), 11, 17, 64, 78

### *Frankfurt/Main*

FIAS (Frankfurt Institute for Advanced Studies | <http://fias.uni-frankfurt.de/>), 78  
Univ. (Goethe University of Frankfurt on Main | <http://www.uni-frankfurt.de/>), 18, 31, 52, 67, 78, 91, 97, 171, 178

### *Freiberg*

IMF TUBAF (Institute for Metal Forming Technical University Bergakademie of Freiberg | <http://www.imf.tu-freiberg.de/>), 137  
TUBAF (Technical University Bergakademie of Freiberg | <http://tu-freiberg.de/>), 137, 178

### *Freiburg*

Univ. (Albert-Ludwigs University of Freiburg | <http://www.uni-freiburg.de/>), 64

### *Göttingen*

Univ. (University of Göttingen | <http://www.uni-goettingen.de/>), 137

### *Geesthacht*

GKSS (Research Center in Geesthacht of the Helmholtz Association | <http://www.hzgd.de/>), 137

### *Giessen*

JLU (Justus Liebig University Giessen | <http://www.uni-giessen.de/>), 18, 52, 78, 91, 178

### *Halle*

MLU (Martin-Luther University of Halle-Wittenberg | <http://www.uni-halle.de/>), 137

### *Hamburg*

DESY (Deutsches Elektronen-Synchrotron A Research Centre of the Helmholtz Association | <http://www.desy.de/>), 11, 31, 64, 82, 137, 164, 171  
Univ. (University of Hamburg | <http://www.uni-hamburg.de/>), 11, 18, 44, 49, 178

### *Hannover*

LUH (Leibniz University of Hannover | <http://www.uni-hannover.de/>), 28, 31

### *Heidelberg*

MPIK (Max Planck Institute for Nuclear Physics | <http://www.mpi-hd.mpg.de/>), 64, 83, 115  
Univ. (University of Heidelberg | <http://www.uni-heidelberg.de/>), 11, 52, 91, 95, 97, 119, 146, 178

### *Jülich*

FZJ (Research Centre Jülich of the Helmholtz Association | <http://www.fz-juelich.de/>), 12, 68, 78, 86, 101, 119, 137, 146, 149

### *Jena*

Univ. (Friedrich-Schiller University of Jena | <http://www.uni-jena.de/>), 11, 28, 32, 178

### *Kaiserslautern*

TU (Technical University of Kaiserslautern | <http://www.uni-kl.de/>), 12

### *Karlsruhe*

KIT (Karlsruhe Institute of Technology | <http://www.kit.edu/>), 12, 58, 137, 146, 171

### *Kassel*

Uni Kassel (University of Kassel | <http://www.uni-kassel.de/>), 178

### *Kiel*

CAU (Christian Albrecht Kiel University | <http://www.uni-kiel.de/>), 137  
IFM-GEOMAR (Leibniz Institute for Marine Science of the Kiel University | <http://www.geomar.de/>), 137

### *Leipzig*

UoC (University of Leipzig | <http://www.zv.uni-leipzig.de/>), 18, 23, 28, 32, 137

### *Münster*

Univ. (University of Münster | <http://www.uni-muenster.de/>), 97, 119

### *Magdeburg*

OVGU (Otto-von-Guericke University Magdeburg | <http://www.avmz.ovgu.de/>), 23, 146

### *Mainz*

JGU (Johannes Gutenberg University of Mainz | <http://www.uni-mainz.de/>), 12, 18, 55, 64, 78, 111, 115, 119, 127

### *Marburg*

Univ. (Philipps University of Marburg | <http://www.uni-marburg.de/>), 97, 101, 178

### *Munich*

LMU (Ludwig Maximilians University of Munich | <http://www.uni-muenchen.de/>), 12, 64, 178  
MPI-P (Max Planck Institute for Physics of Munich | <http://www.mpp.mpg.de/>), 28, 32, 40, 49  
TUM (Technical University of Munich | <http://portal.mytum.de/>), 64, 91, 127, 146

### *Oldenburg*

IPO (Institute of Physics of the University of Oldenburg | <http://www.uni-oldenburg.de/en/physics/>), 28

### *Potsdam*

- AEI (Max Planck Institute for Gravitational Physics (Albert Einstein Institute) | <http://www.aei-potsdam.mpg.de/>), 28, 32
- GFZ (Helmholtz Centre Potsdam GeoForschungsZentrum German Research Centre for Geosciences of the Helmholtz Association | <http://www.gfz-potsdam.de/>), 137

### *Quedlinburg*

- IST (Ionen Strahl Technologie GmbH | <http://www.isttechnologie.de/>), 152
- MiCryon Technik (MiCryon Technik GmbH | <http://www.micryon.de/>), 152

### *Regensburg*

- UR (University of Regensburg | <http://www.uni-regensburg.de/>), 12, 18, 78

### *Rostock*

- Univ. (University of Rostock | <http://www.uni-rostock.de/>), 12, 18, 23, 32, 137

### *Siegen*

- Univ. (University of Siegen | <http://www.uni-siegen.de/>), 18, 91

### *Stuttgart*

- MPI-FKF (Max Planck Institute for Solid State Research | <http://www.fkf.mpg.de/>), 23, 137
- MPI-MF (Max Planck Institute for Metals Research | <http://www.mf.mpg.de/>), 119

### *Tübingen*

- Univ. (Eberhard Karls University of Tübingen | <http://www.uni-tuebingen.de/>), 12, 49, 111, 127

### *Wuppertal*

- UW (University of Wuppertal | <http://www.uni-wuppertal.de/>), 12, 23, 178

### *Zeuthen*

- DESY (Deutsches Elektronen-Synchrotron of the Helmholtz Association | <http://www.desy.de/>), 12, 32, 40, 49, 83, 146, 171

## **Greece**

### *Athens*

- INP NCSR “Demokritos” (Institute of Nuclear Physics of the National Centre for Scientific Research “Demokritos” | <http://www.inp.demokritos.gr/>), 18, 58
- UoA (National and Kapodistrian University of Athens | <http://www.uoa.gr/>), 28, 32, 40, 58, 83, 97

### *Ioannina*

- UI (University of Ioannina | <http://www.uoi.gr/>), 58

### *Thessaloniki*

- AUTH (Aristotle University of Thessaloniki | <http://www.auth.gr/>), 18, 101, 178

## **Hungary**

### *Budapest*

- ELTE (Eötvös Loránd University | <http://www.elte.hu/>), 12
- RKK OU (Rejto Sándor Faculty of Light Industry and Environmental Engineering of the Obuda University | <http://rkk.uni-obuda.hu/>), 127
- Wigner RCP (Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics of the Hungarian Academy of Science | <http://wigner.mta.hu/>), 12, 18, 23, 28, 32, 59, 97, 137, 146

### *Debrecen*

- Atomki (Institute of Nuclear Research of the Hungarian Academy of Science | <http://www.atomki.hu/>), 18, 59
- UD (University of Debrecen | <http://www.unideb.hu/>), 59

### *Szeged*

- US (University of Szeged | <http://www.u-szeged.hu/>), 137

## **India**

### *Aligarh*

- AMU (Aligarh Muslim University | <http://www.amu.ac.in/>), 97

### *Bhubaneswar*

- IOP (Institute of Physics of Bhubaneswar | <http://www.iopb.res.in/>), 59, 97

### *Calcutta*

- BNC (S.N.Bose National Centre for Basic Sciences | <http://www.bose.res.in/>), 28, 32
- JU (Jadavpur University | <http://www.jaduniv.edu.in/>), 178
- SINP (Saha Institute of Nuclear Physics | <http://www.saha.ernet.in/>), 98
- VECC (Variable Energy Cyclotron Centre of the Department of Atomic Energy | <http://www.veccl.ernet.in/>), 97, 111

### *Chandigarh*

- PU (Panjab University | <http://pu.chd.ac.in/>), 59, 98

### *Gurgaon*

- AMITY (Amity University | <http://amity.edu/gurgaon/>), 137

### *Jaipur*

- Univ. (University of Rajasthan | <http://www.uniraj.ernet.in/>), 91, 101

### *Jammu*

- Univ. (University of Jammu | <http://www.jammuuniversity.in/>), 98

### *Manipal*

MU (Manipal University |  
<http://www.manipal.edu/>), 111

### *Mumbai*

BARC (Bhabha Atomic Research Centre of  
the Department of Atomic Energy |  
<http://www.barc.ernet.in/>), 59, 91, 101, 162  
TIFR (Tata Institute of Fundamental  
Research | <http://www.tifr.res.in/>), 23, 59

### *New Delhi*

IUAC (Inter-University Accelerator Center |  
<http://www.iuac.ernet.in/>), 111, 162

### *Varanasi*

BHU (Banaras Hindu University |  
<http://www.bhu.ac.in/>), 127

## **Iran**

### *Tehran*

IPM (Institute for Studies in Theoretical  
Physics and Mathematics of the Institute  
for Research Fundamental Sciences |  
<http://www.ipm.ac.ir/IPM/>), 59

## **Ireland**

### *Dublin*

DIAS (Dublin Institute for Advanced Studies |  
<http://www.dias.ie/>), 23

## **Israel**

### *Jerusalem*

HUJI (Hebrew University of Jerusalem |  
<http://www.huji.ac.il/>), 78

### *Rehovot*

WIS (Weizmann Institute of Science |  
<http://www.weizmann.ac.il/>), 32, 40

### *Tel Aviv*

TAU (Tel Aviv University |  
<http://www.tau.ac.il/>), 64, 78

## **Italy**

### *Bari*

INFN (National Institute for Nuclear Physics,  
Section of Bari | <http://www.ba.infn.it/>),  
12, 28, 59, 98  
UniBa (University of Bari Aldo Moro |  
<http://www.uniba.it/>), 178

### *Bologna*

Centro, ENEA (Bologna Research Centre of  
the Italian National Agency for New  
Technologies, Energy and the Environment |  
<http://www.bologna.enea.it/>), 18  
INFN (National Institute for Nuclear Physics,  
Section of Bologna |  
<http://www.bo.infn.it/>), 59, 98, 171

### *Brescia*

Forgiatura Morandini (Forgiatura Morandini |  
<http://www.morandini.it/>), 78

### *Cagliari*

INFN (National Institute for Nuclear Physics,  
Section of Cagliari |  
<http://www.ca.infn.it/>), 98

### *Catania*

INFN LNS (National Institute for Nuclear  
Physics, National Laboratory of the South |  
<http://www.lns.infn.it/>), 18, 59, 106, 111  
UniCT (University of Catania |  
<http://www.unict.it/>), 23, 98

### *Ferrara*

INFN (National Institute for Nuclear Physics,  
Section of Ferrara | <http://www.fe.infn.it/>),  
55  
UniFe (University of Ferrara |  
<http://www.unife.it/>), 119

### *Florence*

INFN (National Institute for Nuclear Physics,  
Section of Florence |  
<http://www.fi.infn.it/>), 55, 59

### *Frascati*

INFN LNF (National Institute for Nuclear  
Physics, National Laboratory of Frascati |  
<http://www.lnf.infn.it/>), 28, 32, 42, 55, 64,  
83, 119

### *Genova*

ASG (ASG Superconductors D.p.a. |  
<http://www.as-g.it/>), 78  
INFN (National Institute for Nuclear Physics,  
Section of Genova | <http://www.ge.infn.it/>),  
59, 83

### *Legnaro*

INFN LNL (National Institute for Nuclear  
Physics, Legnaro National Laboratories |  
<http://www.lnl.infn.it/>), 98, 111

### *Messina*

UniMe (University of Messina |  
<http://www.unime.it/>), 18, 111

### *Naples*

INFN (National Institute for Nuclear Physics,  
Section of Naples | <http://www.na.infn.it/>),  
12, 18, 28, 55  
Unina (University of Naples Federico II |  
<http://www.unina.it/>), 111

### *Padua*

INFN (National Institute for Nuclear Physics,  
Section of Padua | <http://www.pd.infn.it/>),  
55, 59, 98  
UniPd (University of Padua |  
<http://www.unipd.it/>), 12, 28, 32

### *Pavia*

INFN (National Institute for Nuclear Physics,  
Section of Pavia | <http://www.pv.infn.it/>),  
12, 28, 32, 59

### *Perugia*

INFN (National Institute for Nuclear Physics,  
Section of Perugia |  
<http://www.pg.infn.it/>), 18, 55, 59

### *Pisa*

INFN (National Institute for Nuclear Physics,  
Section of Pisa | <http://www.pi.infn.it/>),  
12, 28, 32, 40, 55, 59, 83  
UniPi (University of Pisa |  
<http://www.unipi.it/>), 42

### *Rome*

ENEA (Italian National Agency for New  
Technologies, Energy and Environment |  
<http://www.enea.it/>), 127  
INFN (National Institute for Nuclear Physics,  
Section of Rome |  
<http://www.roma1.infn.it/>), 55, 59, 98  
Univ. "La Sapienza" (University of Roma "La  
Sapienza" | <http://www.uniroma1.it/>), 119,  
159  
Univ. "Tor Vergata" (University of Rome "Tor  
Vergata" | <http://web.uniroma2.it/>), 55

### *Salerno*

INFN (National Institute for Nuclear Physics,  
Section of Naples | <http://www.sa.infn.it/>),  
45, 98  
UNISA (University of Salerno |  
<http://web.unisa.it/>), 23, 28, 32

### *Trento*

ECT\* (European Center Theoretical Studies in  
Nuclear Physics and Related Areas |  
<http://www.estar.eu/>), 18  
UniTn (University of Trento |  
<http://www.unitn.it/>), 137

### *Trieste*

INFN (National Institute for Nuclear Physics,  
Section of Trieste | <http://www.ts.infn.it/>),  
64  
SISSA/ISAS (International School for  
Advanced Studies | <http://www.sissa.it/>),  
12, 28, 32

### *Turin*

INFN (National Institute for Nuclear Physics,  
Section of Turin | <http://www.to.infn.it/>),  
28, 32, 47, 55, 59, 64, 78, 98, 119, 178  
UniTo (University of Turin |  
<http://www.unito.it/>), 12, 18, 47, 50

### *Udine*

Uniud (University of Udine |  
<http://www.uniud.it/>), 156

### *Vercelli*

UPO (Amedeo Avogadro Piemonte Eastern  
University | <http://www.unipmn.it/>), 98

### *Viterbo*

UNITUS (University of Tuscia |  
<http://www3.unitus.it/>), 159

## **Japan**

### *Chiba*

NIRS (National Institute of Radiological  
Sciences | <http://www.nirs.go.jp/>), 122  
Toho Univ. (Toho University Foundation |  
<http://www.toho-u.ac.jp/>), 64

### *Fukuoka*

Kyushu Univ. (Kyushu University |  
<http://www.kyushu-u.ac.jp/>), 28, 111

### *Hiroshima*

Hiroshima Univ. (Hiroshima University |  
<http://www.hiroshima-u.ac.jp/>), 87

### *Kobe*

Kobe Univ. (Kobe University |  
<http://www.kobe-u.ac.jp/>), 18

### *Kochi*

KUT (Kochi University of Technology |  
<http://www.kochi-tech.ac.jp/>), 23

### *Kyoto*

KSU (Kyoto Sangyo University |  
<http://www.kyoto-su.ac.jp/>), 28, 32, 127  
Kyoto Univ. (Kyoto University |  
<http://www.kyoto-u.ac.jp/>), 12, 119  
RIMS (Research Institute for Mathematical  
Sciences of Kyoto University |  
<http://www.kurims.kyoto-u.ac.jp/>), 28, 32  
YITP (Yukawa Institute for Theoretical  
Physics of Kyoto University |  
<http://www.yukawa.kyoto-u.ac.jp/>), 28

### *Minato*

Keio Univ. (Keio University |  
<http://www.keio.ac.jp/>), 137

### *Morioka*

Iwate Univ. (Iwate University |  
<http://www.iwate-u.ac.jp/>), 18

### *Nagano*

Shinshu Univ. (Shinshu University |  
<http://www.shinshu-u.ac.jp/>), 137

### *Nagoya*

Meiji Univ. (Meiji University |  
<http://www.meiji.ac.jp/cip/>), 12  
Nagoya Univ. (Nagoya University |  
<http://www.nagoya-u.ac.jp/>), 12, 64, 78

### *Osaka*

ISIR (Institute of Scientific and Industrial  
Research of Osaka University |  
<http://www.sanken.osaka-u.ac.jp/>), 142  
Kansai Univ. (Kansai University |  
<http://www.kansai-u.ac.jp/>), 178  
OCU (Osaka City University |  
<http://www.osaka-cu.ac.jp/>), 64

Osaka Univ. (Osaka University | <http://www.osaka-u.ac.jp/>), 18, 119  
RCNP (Research Centre for Nuclear Physics of Osaka University | <http://www.rcnp.osaka-u.ac.jp/>), 18, 68, 87, 91

#### *Sapporo*

Hokkaido Univ. (Hokkaido University | <http://www.hokudai.ac.jp/>), 142

#### *Sendai*

Tohoku Univ. (Tohoku University | <http://www.tohoku.ac.jp/>), 64

#### *Tokyo*

Toho Univ. (Toho University | <http://www.toho-u.ac.jp/>), 45  
Tokyo Tech (Tokyo Institute of Technology | <http://www.titech.ac.jp/>), 12  
UT (University of Tokyo; Centre for Nuclear Study (CNS); Institute for Cosmic Ray Research; Institute Centre for Elementary Particle Physics (ICEPP) | <http://www.u-tokyo.ac.jp/>), 12, 87, 91

#### *Tsukuba*

KEK (High Energy Accelerator Research Organization | <http://legacy.kek.jp/>), 12, 28, 32, 64, 83, 119, 127  
Univ. (University of Tsukuba | <http://www.tsukuba.ac.jp/>), 91

#### *Wako*

RIKEN (RIKEN Wako Institute; Institute of Physical and Chemical Research | <http://www.riken.go.jp/>), 49, 111

#### *Yamagata*

Yamagata Univ. (Yamagata University | <http://www.yamagata-u.ac.jp/>), 64

## **Kazakhstan**

#### *Almaty*

APHI (Fesenkov Astrophysical Institute of the National Centre of Space Researches and Technologies | <http://aphi.kz/>), 12  
INP (Institute of Nuclear Physics of Ministry of Energy of the Republic of Kazakhstan | <http://www.inp.kz/>), 12, 18, 106, 111, 115, 127, 137, 152, 178  
IPT (“Institute of Physics and Technology” LLC “National Scientific-Technology Holding “Parasat” Joint Stock Company of the Ministry of Education and Sciences of the Republic of Kazakhstan | <http://www.sci.kz/>), 91, 152  
KazNU (Al-Farabi Kazakh National University | <http://www.kaznu.kz/>), 18, 186

#### *Astana*

BA INP (Branch of the Astana Institute of Nuclear Physics of Ministry of Energy of

the Republic of Kazakhstan | <http://www.inp.kz/>), 12, 106  
ENU (L.N.Gumilyov Eurasian National University | <http://www.enu.kz/>), 111, 127, 152, 171, 186  
NU (Nazarbayev University | <http://nu.edu.kz/>), 152

#### *Rudny*

RII (Rudny Industrial Institute | <http://rii.kz/>), 137

#### *Ust-Kamenogorsk*

EKSU (Sarsen Amanzholov East Kazakhstan State University | <http://www.vkgu.kz/>), 186  
TRCE (Training and Research Centre of Ecology of the Sarsen Amanzholov East Kazakhstan State University | <http://www.vkgu.kz/>), 127

## **Latvia**

#### *Riga*

IPE (Institute of Physical Energetics | <http://www.innovation.lv/fei/>), 137  
ISSP UL (Institute of Solid State Physics of the University of Latvia | <http://www.cfi.lu.lv/>), 137, 149

## **Macedonia**

#### *Skopje*

UKiM (Ss. Cyril and Methodius University-Skopje | <http://www.ukim.edu.mk/>), 127

## **Mexico**

#### *Cuernavaca*

UNAM (National Autonomous University of Mexico | <http://www.unam.mx/>), 12

#### *Leon*

UG (University of Guanajuato | <http://www.ugto.mx/>), 32

#### *Mexico*

Cinvestav (Centre for Advanced Investigations and Studies of the National Polytechnical Institute | <http://www.cinvestav.mx/>), 59

#### *Puebla*

BUAP (Autonomous University of Puebla | <http://www.buap.mx/>), 50

#### *San Luis Potosi*

UASLP (Autonomous University of San Luis Potosi | <http://www.uaslp.mx/>), 55

## **Moldova**

#### *Chişinău*

ASM (Academy of Sciences of Moldova | <http://www.asm.md/>), 171, 186  
IAP ASM (Institute of Applied Physics of the Academy of Sciences of Moldova |

<http://www.phys.asm.md/>), 18, 24, 78, 101, 152, 171, 178

IC ASM (Institute of Chemistry of the Academy of Sciences of Moldova | <http://chem.asm.md/>), 137

IMB ASM (Institute of Microbiology and Biotechnology of the Academy of Sciences of Moldova | <http://www.imb.asm.md/>), 127, 137

MSU (Moldova State University | <http://usm.md/>), 78

RENAM (Research and Educational Networking Association of Moldova | <http://www.renam.md/>), 171

UnASM (University of Academy of Sciences of Moldova | <http://www.edu.asm.md/>), 156

## Mongolia

### *Ulaanbaatar*

CGL (Central Geological Laboratory | <http://cengeolab.com/>), 127

IPT MAS (Institute of Physics and Technology of the Mongolian Academy of Sciences | <http://www.mas.ac.mn/>), 12, 52, 91, 98, 101, 137

MUST (Mongolian University of Science and Technology | <http://www.must.edu.mn/>), 137, 142, 178

NE<sup>c</sup> (Government of Mongolia the Nuclear Energy Commission | <http://nea.gov.mn/>), 91, 115

NRC NUM (Nuclear Research Center of the National University of Mongolia | <http://nrc.num.edu.mn/>), 106, 111, 115, 152

NUM (National University of Mongolia | <http://www.num.edu.mn/>), 12, 24, 127, 152, 156, 171, 178

## Netherlands

### *Amsterdam*

NIKHEF (National Institute for Subatomic Physics | <http://www.nikhef.nl/>), 40, 98

### *Utrecht*

UU (University of Utrecht | <http://www.uu.nl/>), 98

## New Zealand

### *Auckland*

Univ. (University of Auckland | <http://www.auckland.ac.nz/uoa/>), 59

### *Christchurch*

UC (University of Canterbury | <http://www.canterbury.ac.nz/>), 59, 164

### *Hamilton*

Univ. (University of Waikato | <http://www.waikato.ac.nz/>), 12

## Norway

### *Bergen*

UiB (University of Bergen | <http://www.uib.no/>), 18, 98

### *Oslo*

UiO (University of Oslo | <http://www.uio.no/>), 18, 98

### *Trondheim*

NGU (Geological Survey of Norway | <http://www.ngu.no/>), 137

NTNU (Norwegian University of Science and Technology | <http://www.ntnu.no/>), 12, 28, 127, 159

## Pakistan

### *Islamabad*

QAU (Quaid-i-Azam University | <http://www.qau.edu.pk/>), 59

## Poland

### *Chorzow*

Franko-Term (Franko-Term LTD Company is a Research and Development | <http://frankoterm.w.toruniu.pl/ssstr/>), 78

### *Gdansk*

GUT (Gdańsk University of Technology | <http://pg.edu.pl/>), 127

### *Katowice*

US (University of Silesia in Katowice | <http://www.us.edu.pl/>), 23

### *Kielce*

JKU (Jan Kochanowski University of Humanities and Science | <http://www.ujk.edu.pl/>), 12

### *Krakow*

AGH-UST (AGH University of Science and Technology | <http://www.agh.edu.pl/>), 115, 137, 142

CYFRONET (Academic Computer Centre CYFRONET of the AGH-University Science and Technology | <http://www.cyfronet.krakow.pl/>), 171

JU (Jagiellonian University in Kraków | <http://www.uj.edu.pl/>), 23, 28, 137, 186

NINP PAS (Henryk Niewodniczański Institute of Nuclear Physics of the Polish Academy of Sciences | <http://www.ifj.edu.pl/>), 12, 18, 28, 83, 91, 98, 101, 106, 111, 115, 119, 122, 127, 137, 162, 164, 178

### *Lodz*

UL (University of Łódź | <http://www.uni.lodz.pl/>), 12, 29, 91, 127, 186

### *Lublin*

UMCS (Marie Curie-Skłodowska University in Lublin | <http://www.umcs.lublin.pl/>), 12,



18, 78, 115, 127, 137, 149, 152, 178

#### *Olsztyn*

UWM (University of Warmia and Mazury in Olsztyn | <http://www.uwm.edu.pl/>), 137

#### *Opole*

UO (University of Opole | <http://www.uni.opole.pl/>), 127

#### *Otwock-Swierk*

NCBJ (National Centre for Nuclear Research | <http://www.ncbj.gov.pl/>), 12, 18, 32, 59, 78, 87, 91, 98, 101, 115, 119, 127, 137, 152, 162, 178

#### *Poznan*

AMU (Adam Mickiewicz University in Poznań | <http://www.guide.amu.edu.pl/>), 23, 127, 137, 159, 186

GPCC (Greater Poland Cancer Center | <http://www.wco.pl/>), 162

IMP PAS (Institute of Molecular Physics of the Polish Academy of Sciences | <http://www.ifmpan.poznan.pl/>), 23

#### *Siedlce*

UPH (University of Natural Sciences and Humanities | <http://www.uph.edu.pl/>), 137

#### *Szczecin*

US (University of Szczecin | <http://www.usz.edu.pl/>), 156

WPUT (West Pomeranian University of Technology in Szczecin | <http://www.zut.edu.pl/>), 137

#### *Torun*

UMK (Nicolaus Copernicus University | <http://www.umk.pl/>), 152

#### *Warsaw*

HIL WU (Heavy Ion Laboratory of Warsaw University | <http://www.slj.uw.edu.pl/>), 106

IEL (Elektrotechnical Institute | <http://www.iel.waw.pl/>), 78, 98

IEP WU (Institute of Experimental Physics of Warsaw University | <http://en.ifd.fuw.edu.pl/>), 106

INCT (Institute of Nuclear Chemistry and Technology | <http://www.ichtj.waw.pl/>), 137, 152

IPC PAS (Institute of Physical Chemistry of the Polish Academy of Sciences | <http://ichf.edu.pl/>), 23

ITR (Tele and Radio Research Institute | <http://www.itr.org.pl/>), 152

NCAC PAS (Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences | <http://www.camk.edu.pl/>), 28

UW (University of Warsaw | <http://www.uw.edu.pl/>), 18, 28, 32, 50, 59,

64, 111

WUT (Warsaw University of Technology | <http://www.pw.edu.pl/>), 18, 23, 78, 91, 95, 98, 101, 178

#### *Wroclaw*

ILT&SR PAS (Institute of Low Temperature and Structure Research of the Polish Academy of Sciences | <http://www.int.pan.wroc.pl/>), 78

UW (University of Wroclaw | <http://www.uni.wroc.pl/>), 29, 32, 127, 137, 178

WUT (Wroclaw University of Technology | <http://www.pwr.wroc.pl/>), 137

## **Portugal**

#### *Lisbon*

UL (University of Lisbon | <http://www.ul.pt/>), 179

## **Republic of Korea**

#### *Chongju*

CBNU (Chungbuk National University | <http://www.chungbuk.ac.kr/>), 12, 59

#### *Daegu*

KNU (Kyungpook National University | <http://en.knu.ac.kr/>), 12

#### *Daejeon*

IBS (Institute for Basic Science | <http://www.ibs.re.kr/>), 18

KAERI (Korea Atomic Energy Research Institute | <http://www.kaeri.re.kr:8080/>), 127

NFRI (National Fusion Research Institute | <http://www.nfri.re.kr/>), 146

#### *Gangneung*

GWNU (Gangneung-Wonju National University | <http://www.gwnu.ac.kr/>), 98

#### *Kwangju*

CNU (Chonnam National University | <http://www.jnu.ac.kr/>), 59

#### *Naju*

DU (Dongshin University; Laboratory for High Energy Physics | <http://www.dsu.ac.kr/>), 59

#### *Namwon*

SU (Seonam University | <http://www.seonam.ac.kr/>), 59

#### *Pohang*

PAL (Pohang Accelerator Laboratory | <http://pal.postech.ac.kr/>), 127

#### *Seoul*

Dawonsys (Company "Dawonsys 'o., Ltd" | <http://www.dawonsys.co.kr/>), 127

EWU (Ewha Womans University | <http://www.ewha.ac.kr/>), 50

KU (Korea University | <http://www.korea.ac.kr/>), 59  
Konkuk Univ. (Konkuk University | <http://www.kku.ac.kr/>), 59  
SNU (Seoul National University | <http://www.snu.ac.kr/>), 12, 18  
SNUE (Seoul National University of Education | <http://www.snue.ac.kr/>), 59

## Romania

### *Baia Mare*

TUCN-NUCBM (Technical University of Cluj-Napoca - North University Center of Baia Mare | <http://www.utcluj.ro/>), 127, 138

### *Bucharest*

CNMN (National Centre for Micro and Nanomaterials of the University Politehnica of Bucharest | <http://www.mocronanotech.ro/>), 138  
IFA (Institute of Atomic Physics | <http://www.ifa-mg.ro/>), 171, 179  
IFIN-HH (Horia Hulubei National Institute of Physics and Nuclear Engineering | <http://www.nipne.ro/>), 18, 23, 29, 32, 52, 55, 79, 91, 106, 111, 115, 119, 127, 137, 142, 146, 149, 171, 179  
INCDIE ICPE-CA (National Institute of Research and Development in Electrical Engineering ICPE-CA | <http://www.icpe-ca.ro/>), 79, 87, 91, 101, 127, 137, 146  
INFLPR (National Institute for Laser, Plasma and Radiation Physics | <http://www.inflpr.ro/>), 137, 152  
INOE2000 (National Institute for Research and Development in Optoelectronics | <http://inoe.inoe.ro/>), 79  
ISS (Institute for Space Sciences | <http://www.space-science.ro/>), 50, 91, 98, 101, 127, 138, 156, 164, 179  
NIMP (National Institute of Materials Physics | <http://www.infim.ro/>), 138  
N&V (<http://www.nuclearvacuum.ro/>), 107  
UB (University of Bucharest | <http://www.unibuc.ro/>), 18, 91, 115, 127, 138, 159, 162, 179, 186  
UMF (University of Medicine and Pharmacy "Carol Davila" - Bucharest' | <http://www.umf.ro/>), 101, 138, 156, 162  
UPB (University Politehnica of Bucharest | <http://www.upb.ro/>), 138, 149  
UTM (Titu Maiorescu University | <http://www.utm.ro/>), 138

### *Cluj-Napoca*

INCDTIM (National Institute for Research and Development of Isotopic and Molecular Technologies | <http://www.itim-cj.ro/>), 138, 171, 179  
RA BC-N (Romanian Academy Cluj-Napoca Branch | <http://www.acad-cluj.ro/>), 138  
UBB (Babeş-Bolyai University | <http://www.ubbcluj.ro/>), 138  
UTC-N (Technical University of Cluj-Napoca | <http://utcluj.ro/>), 23, 138

### *Constanța*

NIMRD (National Institute for Marine Research and Development "Grigore Antipa" | <http://www.rmri.ro/>), 127  
UOC ("Ovidius" University of Constanta | <http://www.univ-ovidius.ro/>), 91, 128, 138

### *Craiova*

UC (University of Craiova | <http://www.ucv.ro/>), 138

### *Galați*

UG (University of Galați | <http://www.ugal.ro/>), 128

### *Iasi*

IBR (Institute of Biological Research Iași of the National Institute of Research and Development for Biological Sciences | <http://www.dbioro.eu/>), 157  
NIRDTP (National Institute of Research and Development for Technical Physics | <http://www.phys-iasi.ro/>), 138  
UAI (University "Apollonia" of Iași | <http://univapollonia.ro/>), 138  
UAIC (Alexandru Ioan Cuza University of Iași | <http://www.uaic.ro/>), 101, 128, 138, 157, 159  
USAMV (University of Agricultural Sciences and Veterinary Medicine | <http://www.uaiasi.ro/>), 138

### *Oradea*

UO (University of Oradea | <http://www.uoradea.ro/>), 128

### *Pitești*

SCN (Institute for Nuclear Research - Pitești | <http://www.nuclear.ro/>), 128, 138  
UPIT (University of Pitești | <http://www.upit.ro/>), 138

### *Râmnicu Vâlcea*

I.C.S.I. (National Research and Development Institute for Cryogenics and Isotopic Technologies | <http://www.icsi.ro/>), 128

### *Târgoviște*

UVT (VALAHIA University of Târgoviște | <http://www.valahia.ro/>), 128, 146

### *Timișoara*

- CCTFA (Center for Fundamental and Advanced Technical Research of the Romanian Academy, Branch Timișoara Filiala Timișoara | <http://acad-tim.tm.edu.ro/cctfa>), 119
- LMF CCTFA (Laboratory of Magnetic Fluids of the Center for Fundamental and Advanced Technical Research of the Romanian Academy, Branch Timișoara | <http://acad-tim.tm.edu.ro/cctfa>), 138
- RA TB (Romanian Academy Timișoara Branch | <http://acad-tim.tm.edu.ro/>), 138
- UPT (Politehnica University of Timișoara | <http://www.upt.ro/>), 138
- UVT (West University of Timișoara | <http://www.uvt.ro/>), 23, 138

### **Russia**

#### *Alexandrov*

- VNIISIMS (Russian Research Institute for the Synthesis of Minerals | <http://vniisims.ru/>), 119

#### *Arkhangelsk*

- NSMU (North State Medical University | <http://www.nsmu.ru/>), 186
- NArFU (Northern (Arctic) Federal University named after M.B.Lomonosov | <http://narfu.ru/>), 165, 186

#### *Astrakhan*

- ASU (Astrakhan State University | <http://asu.edu.ru/>), 157

#### *Belgorod*

- BelSU (Belgorod National Research State University | <http://www.bsu.edu.ru/>), 13, 24, 79, 139, 186

#### *Borok*

- IBIW RAS (Federal State Budgetary Institution of Science “I.D.Papanin Institute for the Biology of Inland Waters of the Russian Academy of Sciences” | <http://ibiw.ru/>), 128
- IPE RAS (Federal State Budgetary Institution of Science “Schmidt Institute of the Physics of the Earth of the Russian Academy of Sciences” | <http://old.ifz.ru/>), 160

#### *Cheboksary*

- ChSU (I.N.Ulyanov Chuvash State University | <http://www.chuvsu.ru/>), 111

#### *Chernogolovka*

- BInEPCP RAS (Federal State Budgetary Institution of Science “Branch of the Institute of Energy Problems for Chemical Physics of the Russian Academy of Sciences” | <http://binep.ac.ru/>), 152

- ISMAN RAS (Federal State Budgetary Institution of Science “Institute of Structural Macrokinetics and Materials Science of the Russian Academy of Sciences” | <http://www.ism.ac.ru/>), 91

- ISSP RAS (Federal State Budgetary Institution of Science “Institute of Solid State Physics of the Russian Academy of Sciences” | <http://issp3.issp.ac.ru/>), 139, 152

- LITP RAS (Federal State Budgetary Institution of Science “L.D.Landau Institute for Theoretical Physics of the Russian Academy of Sciences” | <http://www.itp.ac.ru/>), 13, 29, 32, 172

- SCC IPCP RAS (Federal State Budgetary Institution of Science “Supercomputer Centre of the Institute of Problems of Chemical Physics of the Russian Academy of Sciences” | <http://www.icp.ac.ru/>), 172

#### *Dimitrovgrad*

- SSC RIAR (Open Joint Stock Company “State Scientific Centre Research Institute of Atomic Reactors” Rosatom State Nuclear Energy Corporation, JSC “Atomenergoprom” | <http://www.niiar.ru/>), 111

#### *Dolgoprudny*

- MIPT (Moscow Institute of Physics and Technology (State University) | <http://mipt.ru/>), 59, 119, 139, 149, 186

#### *Dubna*

- BSINP MSU (Branch of the Skobeltsyn Institute of Nuclear Physics of the Lomonosov Moscow State University | <http://www.msu.dubna.ru/>), 47, 101, 186
- Diamant (Diamant LLC | <http://diamant-sk.ru/>), 128, 139
- Dubna Univ. (Moscow Region State Educational Institution for Higher Education Dubna University | <http://www.uni-dubna.ru/>), 128, 139, 146, 164, 172, 179, 186
- IAS “Omega” (Institute for Advanced Studies “Omega” | <http://dubna-cluster.ru/participants/37.htm/>), 101
- PELCOM (“Pelcom Dubna Mashinostroitelnny Zavod” | <http://pelcom.ru/>), 79
- Progresstech (Dubna “Progresstech” | <http://dubna-oez.ru/>), 79
- RDH-9 (Radiological Department of Hospital № 9 | <http://ro.ms9.medic.ina.tel.dubna.tel/>), 162

- SCC “Dubna” (“Dubna” Satellite Communication Centre, Branch of the Federal State Unitary Enterprise “Russian Satellite Communication Company” | <http://www.rsc.ru/>), 172
- SEZ “Dubna” (Special Economic Zone in Dubna | <http://dubna.oez.ru/>), 172
- Trackpore Technology (Closed Joint Stock Company “Trackpore Technology” Membrane Technologies and the Future Branch of the Dubna | <http://www.trackpore.ru/>), 152
- Fryazino*
- ISTOK (Joint Stock Company “Research and Production Corporation “ISTOK” named after Shokin” | <http://www.istokmw.ru/>), 79
- Gatchina*
- PNPI (Federal State Budgetary Institution “B.P.Konstantinov Petersburg Nuclear Physics Institute” of the National Research Centre “Kurchatov Institute” | <http://www.pnpi.spb.ru/>), 13, 18, 24, 32, 37, 42, 59, 64, 79, 87, 98, 107, 111, 115, 119, 128, 139, 146, 160, 172, 179
- Irkutsk*
- ISDCT SB RAS (Federal State Budgetary Institution of Science “Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences” | <http://www.idstu.irk.ru/>), 13
- ISU (Irkutsk State University | <http://isu.su/>), 18, 50
- LI SB RAS (Federal State Budgetary Institution of Science “Limnological Institute of the Siberian Branch of the Russian Academy of Sciences” | <http://www.lin.irk.ru/>), 128
- Ivanovo*
- ISU (Ivanovo State University | <http://ivanovo.ac.ru/>), 13, 186
- ISUCT (Ivanovo State University of Chemistry and Technology | <http://main.isuct.ru/>), 128
- IS‘ RAS (Federal State Budgetary Institution of Science “Institute of Solution Chemistry of the Russian Academy of Sciences” | <http://www.isc-ras.ru/>), 13
- Izhevsk*
- UdSU (Udmurtia State University | <http://udsu.ru/>), 128
- Kaliningrad*
- IKBFU (Immanuel Kant Baltic Federal University | <http://www.kantiana.ru/>), 139
- Kazan*
- Compressormash (Open Joint Stock Company “Kazancompressormash” | <http://compressormash.ru/>), 79
- KFU (Kazan (Volga Region) Federal University | <http://kpfu.ru/>), 13, 24
- KNRTU (Kazan National Research Technological University | <http://www.kstu.ru/>), 139
- Spetshmash (Ltd. “Research and Production Enterprise Spetshmash” | <http://spmsh.ru/>), 79
- Kostroma*
- KSU (Kostroma State University | <http://ksu.edu.ru/>), 186
- Krasnodar*
- KSU (Kuban State University | <http://kubsu.ru/>), 152, 186
- Krasnoyarsk*
- KIP SB RAS (Federal State Budgetary Institution of Science “Kirensky Institute of Physics, Siberian Branch of the Russian Academy of Sciences” | <http://www.kirensky.ru/>), 24
- SibFU (Siberian Federal University | <http://www.sfu-kras.ru/>), 139
- Moscow*
- Atomenergomach (Closed Joint Stock Company “Atomenergomach” | <http://www.cftp-aem.ru/>), 101, 128
- Cryogenmash (Public Joint Stock Company “Cryogenmash” | <http://cryogenmash.ru/>), 79
- ENES (LLC “Engineering Center of Nuclear Equipment Strength” | <http://www.icpmae.ru/>), 143
- GC RAS (Federal State Budgetary Institution of Science “Geophysical Center of the Russian Academy of Sciences” | <http://www.gcras.ru/>), 138
- GIN RAS (Federal State Budgetary Institution of Science “Geological Institute of the Russian Academy of Sciences” | <http://www.ginras.ru/>), 128
- GPI RAS (Federal State Budgetary Institution of Science “General Physics Institute of the Russian Academy of Sciences” | <http://www.gpi.ru/>), 120, 128, 149, 152, 179
- Geliymash (Open Joint Stock Company “Researching and Production Association of Helium Engineering” | <http://geliymash.ru/>), 79, 142
- HTDC (High-Tech Diagnostic Centre | <http://www.uicorp.ru/>), 107

- IA RAS (Federal State Budgetary Institution of Science “Institute of Archaeology of the Russian Academy of Sciences” | <http://archaeolog.ru/>), 138
- IBMC (Federal State Budgetary Institution of Science Institute of Biomedical Chemistry | <http://www.ibmc.msk.ru/>), 138
- IBMP RAS (Federal State Budgetary Institution of Science “State Scientific Centre of the Russian Federation - Institute for Biomedical Problems of the Russian Academy of Sciences” | <http://www.imbp.ru/>), 79, 157, 162
- IC RAS (Federal State Budgetary Institution of Science “A.V.Chubnikov Institute of Crystallography of the Russian Academy of Sciences” | <http://www.crys.ras.ru/>), 138, 152
- ICS RAS (Federal State Budgetary Institute of Science “V.A. Trapeznikov Institute of Control Sciences of the Russian Academy of Sciences” | <http://www.ipu.ru/>), 179
- IEPT RAS (Federal State Budgetary Institution of Science “Institute of Earthquake Prediction Theory and Mathematical Geophysics of the Russian Academy of Sciences” | <http://www.mitp.ru/>), 138
- IGEM RAS (Federal State Budgetary Institution of Science “Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry of the Russian Academy of Sciences” | <http://www.igem.ru/>), 138, 159
- IGIC RAS (Federal State Budgetary Institution of Science “Kurnakov Institute of General and Inorganic Chemistry of the Russian Academy of Sciences” | <http://www.igic.ras.ru/>), 138
- IHNA Ph RAS (Federal State Budgetary Institution of Science “Institute of Higher Nervous Activity and Neurophysiology of the Russian Academy of Sciences” | <http://www.ihna.ru/>), 157
- IITP RAS (Federal State Budgetary Institute of Science “Institute for Information Transmission Problems (Kharkevich Institute) of the Russian Academy of Sciences” | <http://iitp.ru/>), 171
- IKI RAS (Federal State Budgetary Institution of Science “Space Research Institute of the Russian Academy of Sciences” | <http://www.iki.rssi.ru/>), 128, 159
- IMET RAS (Federal State Budgetary Institution of Science “A.A.Baikov Institute of Metallurgy and Materials Science of the Russian Academy of Sciences” | <http://www.imet.ac.ru/>), 138
- IMM RAS (Federal State Budgetary Institution of Science “Institute for Mathematical Modeling of the Russian Academy of Sciences” | <http://www.imamod.ru/>), 12
- INEUM (Institute of Electronic Control Computes named after I.S.Bruk | <http://www.ineum.ru/>), 143
- INMI RAS (Federal State Budgetary Institution of Science “Winogradsky Institute of Microbiology of the Russian Academy of Sciences” | <http://www.inmi.ru/>), 138
- INTRA (Closed Joint Stock Company “INTRA” | <http://www.intra-zao.ru/>), 115
- IPCE RAS (Federal State Budgetary Institution of Science “A.N.Frumkin Institute of Physical Chemistry and Electrochemistry of the Russian Academy of Sciences” | <http://www.phyche.ac.ru/>), 111, 128, 138
- IPE RAS (Federal State Budgetary Institution of Science “Shmidt Institute of Physics of the Earth of the Russian Academy of Sciences” | <http://www.ifz.ru/>), 138
- IPMech RAS (Federal State Budgetary Institution of Science “Institute for Problems in Mechanics of the Russian Academy of Sciences” | <http://www.ipmnet.ru/>), 179
- ISP RAS (Federal State Budgetary Institution of Science “Institute for System Programming of the Russian Academy of Sciences” | <http://www.ispras.ru/>), 171
- ISPM RAS (Federal State Budgetary Institution of Science “Enikolopov Institute of Synthetic Polymeric Materials of the Russian Academy of Sciences” | <http://www.ispm.ru/>), 138, 152
- IITEP (Federal State Budgetary Institution “Russian Federation State Scientific Centre - Alikhanov Institute for Theoretical and Experimental Physics” of the National Research Centre “Kurchatov Institute” | <http://www.itep.ru/>), 12, 29, 32, 40, 52, 59, 79, 91, 95, 98, 107, 115, 119, 128, 138, 157, 164, 171, 179
- ITT-Group (“ITT-Group”), 107
- KIAM RAS (Federal State Budgetary Institution of Science “Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences” |

- <http://www.keldysh.ru/>), 171, 179
- LPI RAS (Federal State Budgetary Institution of Science “P.N.Lebedev Physical Institute of the Russian Academy of Sciences” | <http://www.lebedev.ru/>), 12, 29, 32, 40, 59, 64, 79, 87, 91, 152
- MATI (Russian State Technological University | <http://www.mati.ru/>), 152
- MI RAS (Federal State Budgetary Institution of Science “Steklov Mathematical Institute of the Russian Academy of Sciences” | <http://www.mi.ras.ru/>), 13, 23, 29, 32
- MIEM (Moscow Institute of Electronics and Mathematics | <http://miem.hse.ru/>), 152
- MIET (National Research University of Electronic Technology | <http://www.miet.ru/>), 138
- MIREA (Moscow State University Information Technology, Radioengineering and Electronics | <http://www.mirea.ru/>), 23
- MISiS (National University of Sciens and Technology “MISiS” | <http://www.misis.ru/>), 138
- MITHT (Lomonosov Moscow University of Fine Chemical Technology | <http://www.mitht.ru/>), 138
- MPEI (National Research University “Moscow Power Engineering Institute” | <http://mpei.ru/>), 171, 186
- MSMU (I.M. Sechenov First Moscow State Medical University | <http://www.mma.ru/>), 152
- MSU (Lomonosov Moscow State University | <http://www.msu.ru/>), 13, 18, 29, 32, 40, 68, 79, 111, 128, 138, 157, 159, 164, 171, 179
- MUCTR (Mendeleev University of Chemical Technology of Russia | <http://www.muctr.ru/>), 111, 152
- NIKIET (Joint Stock Company “A.N.Dollezhal Research and Development Institute of Power Engineering” | <http://www.nikiet.ru/>), 59, 138, 142
- NNRU “MEPhI” (National Nuclear Research University “MEPhI” | <http://www.mephi.ru/>), 18, 23, 50, 53, 59, 68, 79, 83, 95, 98, 111, 115, 138, 146, 179, 186
- NRC KI (National Research Centre “Kurchatov Institute” | <http://www.nrcki.ru/>), 18, 23, 79, 87, 98, 111, 115, 120, 128, 138, 146, 172, 179
- NRU HSE (National Research University “Higher School of Economics” | <http://www.hse.ru/>), 23, 29
- PFUR (Peoples’ Friendship University of Russia | <http://www.rudn.ru/>), 13, 23, 179
- PIN RAS (Paleontological Institute of the Russian Academy of Sciences | <http://www.paleo.ru/>), 159
- Profimontazhservis (Open Joint Stock Company “PROFIMONTAZHSERVISP”), 143
- RADON (Federal State Unitary Enterprise - United Ecological, Scientific and Research Centre of Decontamination of Radioactive Waste and Environmental Protection “RADON” | <http://www.radon.ru/>), 115
- RCC MSU (Research Computer Centre of the M.V.Lomonosov Moscow State University | <http://www.srcc.msu.ru/>), 171, 179
- RIPN (Russian Institute for Public Networks | <http://www.ripn.net/>), 171
- RIVS (I.I.Mechnikov Research Institute of Vaccines and Sera | <http://www.instmech.ru/>), 152
- RMAPE (Russian Medical Academy of Postgraduate Education | <http://www.rmapo.ru/>), 162
- RSCC (Federal State Unitary Enterprise “Russian Satellite Communications Company” | <http://www.rsccl.ru/>), 172
- SAI MSU (Sternberg Astronomical Institute of the M.V.Lomonosov Moscow State University | <http://www.sai.msu.ru/>), 159
- SC “VNIINM” (Stock Company “A.A.Bochvar High-Technology Research Institute of Inorganic Materials” | <http://www.bochvar.ru/>), 115, 139
- SCC RAS (Scientific Council for Cybernetics of the Russian Academy of Sciences | <http://www.ras.ru/>), 13, 32
- SF IPh (Federal State Budgetary Institution of Science “State Foundation Institute of Pharmacology” | <http://www.academpharm.ru/>), 157
- SINP MSU (Skobeltsyn Institute of Nuclear Physics of the M.V.Lomonosov Moscow State University | <http://www.sinp.msu.ru/>), 13, 18, 23, 32, 50, 53, 59, 64, 68, 91, 98, 111, 115, 120, 128, 138, 152, 172, 179, 186
- SSDI (Joint Stock Company “State Specialized Design Institute” | <http://oagosp.ru/>), 83, 143
- SYSTEMATOM (Closed Joint Stock Company “Nuclear and Radiation Safety Systems” | <http://www.systematom.ru/>), 143

- Technomedexport (Closed Joint Stock Company "Technomedexport"), 152
- VIGG RAS (Federal State Budgetary Institution of Science "Vavilov Institute of General Genetics of the Russian Academy of Sciences" | <http://www.vigg.ru/>), 162
- VNIIA (Federal State Unitary Enterprise "All-Russian Research Institute of Automatics" Russian Federal Atomic Energy Agency | <http://www.vniia.ru/>), 128
- VNIIMS (Federal Agency of Technical Regulating and Metrology National Metrology Institute All-Russian Research Institute of Metrological Service | <http://www.vniims.ru/>), 29, 32
- Moscow, Troitsk*
- HPPI RAS (Federal State Budgetary Institution of Science "Institute for High Pressure Physics of the Russian Academy of Sciences" | <http://www.hppei.troitsk.ru/>), 23, 139
- INR RAS (Federal State Budgetary Institution of Science "Institute for Nuclear Research of the Russian Academy of Sciences" | <http://www.inr.ac.ru/>), 13, 18, 29, 32, 42, 50, 53, 55, 59, 64, 79, 83, 87, 91, 98, 111, 115, 120, 128, 139, 146, 164, 172
- ISAN (Federal State Budgetary Institution of Science "Institute of Spectroscopy of the Russian Academy of Sciences" | <http://isan.troitsk.ru/>), 139
- Moscow, Zelenograd*
- RIMST (Closed Joint Stock Company "Research Institute of Material Science and Technology" | <http://www.niimv.ru/>), 111
- Nauchny*
- CrAO RAS (Federal State Budgetary Institution of Science "Crimean Astrophysical Observatory of the Russian Academy of Sciences" | <http://craocrimca.ru/>), 50
- Nizhny Novgorod*
- IAP RAS (Federal State Budgetary Institution of Science "Institute of Applied Physics of the Russian Academy of Sciences" | <http://www.iapras.ru/>), 83, 107
- IPM RAS (Federal State Budgetary Institution of Science "Institute for Physics of Microstructures of the Russian Academy of Sciences" | <http://ipmras.ru/>), 139, 146
- UNN (N.I.Lobachevsky State University of Nizhny Novgorod (National Research University) | <http://www.unn.ru/>), 139, 172
- Novosibirsk*
- BIC SB RAS (Federal State Budgetary Institution of Science "Boreskov Institute of Catalysis of the Siberian Branch of the Russian Academy of Sciences" | <http://www.catalysis.ru/>), 160
- BINP SB RAS (Federal State Budgetary Institution of Science "Budker Institute of Nuclear Physics of the Siberian Branch of the Russian Academy of Sciences" | <http://www.inp.nsk.su/>), 13, 37, 79, 83, 98, 107, 172
- IM SB RAS (Federal State Budgetary Institution of Science "Sobolev Institute of Mathematics of the Siberian Branch of the Russian Academy of Sciences" | <http://math.nsc.ru/>), 13
- ISP SB RAS (Federal State Budgetary Institution of Science "A.V.Rzhanov Institute of Semiconductor Physics of the Siberian Branch of the Russian Academy of Sciences" | <http://www.isp.nsc.ru/>), 152
- NSU (Novosibirsk State University | <http://www.nsu.ru/>), 59
- Obninsk*
- IPPE (Joint Stock Company "State Scientific Centre of the Russian Federation - Institute of Physics and Power Engineering" | <http://www.ippe.ru/>), 101, 128, 139
- MRRC (A.Tsyb Medical Radiological Research Centre - Branch of the National Medical Radiological Centr of the Health of the Russian Federation | <http://mrrc.obninsk.ru/>), 101
- REATRACK-Filter (REATRACK-Filter LLC | <http://www.reatrack.ru/>), 152
- Omsk*
- OB IM SB RAS (Federal State Budgetary Institution of Science "Institute of Mathematics of the Siberian Branch of the Russian Academy of Sciences" | <http://ofim.oscsbras.ru/>), 47
- OmSU (F.V. Dostoevsky Omsk State University | <http://www.omsu.ru/>), 19
- Pereslavl-Zalesskiy*
- PSI RAS (Federal State Budgetary Institution of Science "Program Systems Institute of the Russian Academy of Sciences" | <http://www.botik.ru/PSI/>), 172
- Perm*
- ICMM UrB RAS (Federal State Budgetary Institution of Science "Institute of Continuous Media Mechanics of the Russian Academy of Sciences Ural Branch" | <http://www.icmm.ru/>), 139

- ITCh UrB RAS (Federal State Budgetary Institution of Science “Institute of Technical Chemistry of the Russian Academy of Sciences Ural Branch” | <http://www.itch.perm.ru/>), 139
- PSNRU (Perm State National Research University | <http://www.psu.ru/>), 13
- Petrozavodsk*
- IG KRS RAS (Federal State Budgetary Institution of Science “Institute of Geology Karelian Research Center of the Russian Academy of Sciences” | <http://ig.krc.karelia.ru/>), 139
- PetrSU (Petrozavodsk State University | <http://petrsu.karelia.ru/>), 32
- Podolsk*
- GIDROPRESS (Open Joint Stock Company “Experimental & Design Organization “GIDROPRESS” | <http://www.gidropress.podolsk.ru/>), 139
- Protvino*
- IHEP (Federal State Budgetary Institution “Russian Federation State Scientific Centre - Institute for High Energy Physics” of the National Research Centre “Kurchatov Institute” | <http://www.ihep.ru/>), 13, 24, 29, 32, 40, 47, 53, 55, 59, 65, 68, 79, 95, 98, 172, 179
- Puschino*
- IMPB RAS (Federal State Budgetary Institution of Science “Institute of Mathematical Problems of Biology of the Russian Academy of Sciences” | <http://www.impb.ru/>), 172, 179
- IPR RAS (Federal State Budgetary Institution of Science “Institute of Protein Research of the Russian Academy of Sciences” | <http://www.protres.ru/>), 179
- ITEB RAS (Federal State Budgetary Institution of Science “Institute of Theoretical and Experimental Biophysics of the Russian Academy of Sciences” | <http://web.iteb.psn.ru/>), 179
- Rostov-on-Don*
- RIP SFU (Research Institute of Physics of the Southern Federal University | <http://ip.sfedu.ru/>), 139
- SFedU (Southern Federal University | <http://www.sfedu.ru/>), 13, 162
- Ryazan*
- RSU (S.A.Esenin Ryazan State University | <http://www.rsu.edu.ru/>), 83
- Samara*
- SSAU (Samara State Aerospace University | <http://www.ssau.ru/>), 13, 172
- SSU (Samara State University | <http://samsu.ru/>), 13
- Saratov*
- SSU (Saratov State University named after N.G.Chernyshevsky | <http://www.sgu.ru/>), 13, 19, 24, 179
- Sarov*
- VNIIEF (Russian Federal Nuclear Centre - All-Russian Research “Institute of Experimental Physics” | <http://www.vniief.ru/>), 13, 83, 92, 98, 107, 111, 115, 120
- Sevastopol*
- IBSS (A.O.Kovalevsky Institute of Biology of the Southern Seas | <http://www.ibss.inf.net/>), 128
- Simferopol*
- MALDAS (“MALDAS” LLC | <http://www.maldas.uaprom.net/>), 152
- SIMPEX (Research and Production Enterprise “SIMPEX” Joint-Stock Company | <http://www.filter-systems.com/>), 152
- Smolensk*
- SSU (Smolensk State University | <http://www.smolgu.ru/>), 92, 186
- Snezhinsk*
- VNIITF (Russian Federal Nuclear Centre - All-Russian Scientific Research Institute of Technical Physics | <http://www.vniitf.ru/>), 59, 128
- Sochi*
- SRI MP (Federal State Budgetary Institution “Scientific Research Institute of Medical Primatology” | <http://www.primatologia.ru/>), 157
- St. Petersburg*
- Botanic Garden BIN RAS (Federal State Budgetary Institution of Science “Botanic Garden of the V.L.Komarov Botanic Institute of the Russian Academy of Sciences” | <http://www.binran.ru/>), 128
- ETU (Saint Petersburg State Electrotechnical University “LETI” | <http://www.eltech.ru/>), 24
- Electron (Open Joint Stock Company “National Research Institute “Electron” | <http://www.electron.spb.ru/>), 59
- FIP (V.F.Fock Institute of Physics of the Saint Petersburg State University | <http://www.niif.spbu.ru/>), 92, 98, 128, 172, 179
- Hermitage (State Hermitage Museum | <http://www.hermitagemuseum.org/>), 128
- IPTI RAS (Federal State Budgetary Institution of Science “Ioffe Physic I



- Technical Institute of the Russian Academy of Sciences" | <http://www.ioffe.ru/>), 24, 111, 115, 139, 152
- ITMO (National Research University of Information Technologies, Mechanics and Optics | <http://www.ifmo.ru/>), 172
- KB "Arsenal" (Federal State Unitary Enterprise "Arsenal" Design Bureau" | <http://kbarsenal.ru/>), 50
- KRI (V.G.Khlopın Radium Institute | <http://www.khlopın.ru/>), 79, 101, 111, 128
- NIIEFA (D.V.Efremov Scientific Research Institute of Electrophysical Apparatus | <http://www.niiefa.spb.su/>), 107, 179
- NITIOM (Joint Stock Company "Research and Technological Institute of Optical Materials all-Russia Scientific Center "S.I.Vavilov State Optical Institute" | <http://www.goi.ru/>), 149
- Neva-Magnet (Neva-Magnet S&E, Ltd | <http://www.magnet.spb.su/prd2.html/>), 47, 79
- PDMI RAS (Federal State Budgetary Institution of Science "St.Petersburg Department of V.A.Steklov Institute of Mathematics of the Russian Academy of Sciences" | <http://www.pdmi.ras.ru/pdmi/>), 24, 29, 32
- SPSFTU (Saint Petersburg State Forest Technical University | <http://spbftu.ru/>), 128
- SPbSPU (Saint Petersburg Polytechnic University Peter the Great | <http://www.spbstu.ru/>), 13, 165, 172
- SPbSU (Saint Petersburg State University | <http://spbu.ru/>), 13, 19, 24, 29, 79, 95, 115, 139, 172, 186
- Sterlitamak*
- SSPA (Sterlitamak State Pedagogical Academy | <http://www.sspa.edu.ru/>), 139
- Syktuykar*
- DM Komi SC UrB RAS (Federal State Budgetary Institution of Science "Department of Mathematics Komi Sciences Centre of the Russian Academy of Sciences Ural Branch" | <http://www.komisc.ru/>), 68, 79
- Tomsk*
- IHCE SB RAS (Federal State Budgetary Institution of Science "Institute of High Current Electronics of the Siberian Branch of the Russian Academy of Sciences" | <http://www.hcei.tsc.ru/>), 13, 116
- NPI TPU (Nuclear Physics Institute of the National Research Tomsk Polytechnic University | <http://www.npi.tpu.ru/>), 79, 116, 139
- TPU (National Research Tomsk Polytechnic University | <http://tpu.ru/>), 29, 92, 101, 186
- TSU (National Research Tomsk State University | <http://www.tsu.ru/>), 13, 32, 165, 179
- Tula*
- TSPU (Tula State Pedagogical University | <http://tsput.ru/>), 128
- TSU (Tula State University | <http://tsu.tula.ru/>), 139, 186
- Tver*
- TvSU (Tver State University | <http://university.tversu.ru/>), 13, 186
- Vladimir*
- Vladisart ("Vladisart" | <http://www.vladisart.ru/>), 152
- Vladivostok*
- FEFU (Far Eastern Federal University | <http://dvfu.ru/>), 19, 157
- Voronezh*
- VSU (Voronezh State University | <http://www.vsu.ru/>), 24, 111, 115, 128, 186
- Yakutsk*
- NEFU (North-Eastern Federal University | <http://www.s-vfu.ru/>), 186
- Yekaterinburg*
- IMP UB RAS (Federal State Budgetary Institution of Science "M.N.Mikheev Institute of Metal Physics of Ural Branch of the Russian Academy of Sciences" | <http://www.imp.uran.ru/>), 139, 146
- UrFU (Urals Federal University named after the First President of Russia B.N.Yeltsin | <http://urfu.ru/>), 128, 139
- Yoshkar-Ola*
- VSUT (Volga State University of Technology | <http://www.volgatech.net/>), 13
- Zhukovsky*
- MDB (Open Joint Stock Company "Myasishchev Design Bureau" | <http://www.emz-m.ru/>), 59
- Serbia**
- Belgrade*
- INS "VINČA" ("VINČA" Institute of Nuclear Sciences | <http://www.vin.bg.ac.rs/>), 24, 60, 101, 107, 139, 152
- IPB (Institute of Physics Belgrade of the University of Belgrade | <http://www.phy.bg.ac.rs/>), 19, 29, 32, 128
- Univ. (University of Belgrade | <http://www.bg.ac.rs/>), 13, 29, 32, 128

### *Novi Sad*

UNS (University of Novi Sad |  
<http://www.uns.ac.rs/>), 128, 139

## **Slovakia**

### *Banska Bistrica*

UMB (University Mateja Bela |  
<http://www.umb.sk/>), 68, 179

### *Bratislava*

BIONT (Bratislava Ionic Technologies Co. |  
<http://www.biont.sk/>), 152

CU (Comenius University in Bratislava |  
<http://uniba.sk/>), 13, 19, 24, 40, 42, 45, 53,  
55, 101, 112, 116, 128, 139, 152, 157, 186

IEE SAS (Institute of Electrical Engineering  
of the Slovak Academy of Sciences |  
<http://www.elu.sav.sk/>), 83, 116, 128, 152

ILE SAS (Institute of Landscape Ecology of  
the Slovak Academy of Sciences |  
<http://uke.sav.sk/>), 128

IMS SAS (Institute of Measurement Science of  
the Slovak Academy of Sciences |  
<http://www.um.sav.sk/>), 79, 107, 146

IP SAS (Institute of Physics of the Slovak  
Academy of Sciences |  
<http://www.fu.sav.sk/>), 13, 19, 40, 42, 47,  
53, 87, 92, 95, 101, 107, 112, 128

SOSMT (Slovak Office of Standards,  
Metrology and Testing |  
<http://www.unms.sk/>), 101

STU (Slovak University of Technology in  
Bratislava | <http://www.stuba.sk/>), 60, 98

### *Košice*

IEP SAS (Institute of Experimental Physics of  
the Slovak Academy of Sciences in Košice |  
<http://uef.saske.sk/>), 13, 24, 87, 139, 172,  
179

PJSU (Pavol Jozef Šafárik University in  
Košice | <http://www.upjs.sk/>), 79, 87, 92,  
95, 98, 179, 186

TUKE (Technical University of Košice |  
<http://www.tuke.sk/tuke/university>), 24,  
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### *Prešov*

PU (University of Prešov |  
<http://www.unipo.sk/>), 172, 179

### *Žilina*

UŽ (University of Žilina |  
<http://www.uniza.sk/>), 79, 87

## **Slovenia**

### *Ljubljana*

GeoSS (Geological Survey of Slovenia |  
<http://www.geo-zs.si/>), 128

UL (University of Ljubljana |  
<http://www.uni-lj.si/>), 24

## **South Africa**

### *Bellville*

UWC (University of the Western Cape |  
<http://www.uwc.ac.za/>), 153

### *Cape Town*

UCT (University of Cape Town |  
<http://www.uct.ac.za/>), 32, 79, 98, 172, 179  
iThemba LABS (iThemba Laboratory for  
Accelerator Based Sciences |  
<http://www.tlabs.ac.za/>), 19, 83, 107, 112,  
165

### *Johannesburg*

UJ (University of Johannesburg |  
<http://www.uj.ac.za/>), 79

WITS (University of the Witwatersrand |  
<http://www.wits.ac.za/>), 79

### *Port Elizabeth*

NMMU (Nelson Mandela Metropolitan  
University | <http://www.nmmu.ac.za/>), 153

### *Pretoria*

DST (Department of Science and Technology  
Republic of South Africa |  
<http://www.dst.gov.za/>), 186

Necsa (South African Nuclear Energy  
Corporation | <http://www.necsa.co.za/>),  
139

UP (University of Pretoria |  
<http://web.up.ac.za/>), 179

Unisa (University of South Africa |  
<http://www.unisa.ac.za/>), 19, 112, 129

### *Stellenbosch*

SU (Stellenbosch University |  
<http://www.sun.ac.za/>), 19, 112, 129, 179

## **Spain**

### *Barcelona*

IEEC-CSIC (Institute of Space Studies of  
Catalonia of the Spanish National Research  
Council | <http://www.ieec.cat/>), 29

IFAE (Institute for High Energy Physics |  
<http://www.ifae.es/>), 40

### *Bilbao*

UPV/EHU (University of the Basque Country  
| <http://www.enu.es/>), 29

### *Huelva*

UHU (University of Huelva |  
<http://www.uhu.es/>), 112

### *Madrid*

CENIM-CSIC (National Centre for  
Metallurgical Research of the Spanish  
National Research Council |  
<http://www.cenim.csic.es/>), 139

CIEMAT (Research Centre for Energy,  
Environment and Technology |  
<http://www.ciemat.es/>), 60

CSIC (Spanish National Research Council | <http://www.csic.es/>), 112  
IA-CSIC (Institute of Acoustics of the Spanish National Research Council | <http://www.ia.csic.es/>), 153  
ICMM-CSIC (Materials Science Institute of Madrid of the Spanish National Research Council | <http://www.icmm.csic.es/>), 24  
UAM (Autonoma University of Madrid | <http://www.uam.es/>), 60

#### *Oviedo*

UO (University of Oviedo | <http://www.uniovi.es/>), 60

#### *Palma*

UIB (Illes Balears University | <http://www.uib.cat/>), 19

#### *Santander*

IFCA (Institute of Physics of Cantabria of the University of Cantabria | <http://www.ifca.unican.es/>), 60

#### *Santiago de Compostela*

USC (University of Santiago de Compostela | <http://www.usc.es/>), 13

#### *Valencia*

IFIC (Institute for Particle Physics of the University of Valencia | <http://ific.uv.es/>), 29

UPV (Polytechnic University of Valencia | <http://webific.ific.uv.es/>), 143

UV (University of Valencia | <http://www.uv.es/>), 13, 153

### **Sweden**

#### *Göteborg*

Chalmers (Chalmers University of Technology | <http://www.chalmers.se/>), 19, 112

#### *Lund*

LU (Lund University | <http://www.lu.se/>), 13, 19, 92, 98, 112, 172

#### *Stockholm*

SU (Stockholm University | <http://www.su.se/>), 79

#### *Uppsala*

TSL (Svedberg Laboratory of the Uppsala University | <http://www4.tsl.uu.se/tsl/>), 79, 87

### **Switzerland**

#### *Basel*

Uni Basel (University of Basel | <http://www.unibas.ch/>), 60

#### *Bern*

Uni Bern (University of Bern | <http://www.unibe.ch/>), 13, 19

#### *Geneva*

UniGe (University of Geneva | <http://www.unige.ch/>), 87, 92

#### *Lausanne*

EPFL (Ecole Polytechnique Fédérale de Lausanne | <http://www.epfl.ch/>), 98

#### *Villigen*

PSI (Paul Scherrer Institute | <http://www.psi.ch/>), 13, 24, 60, 87, 92, 112, 120, 129, 139

#### *Zurich*

ETH (Swiss federal Institute of Technology Zurich | <http://www.ethz.ch/>), 24, 60, 92, 139, 179

UZH (University of Zurich | <http://www.uzh.ch/>), 60, 65, 120

### **Taiwan**

#### *Chung-Li*

NCU (National Central University | <http://www.ncu.edu.tw/>), 60

#### *Hsinchu*

NSRRC (National Synchrotron Radiation Research Center | <http://www.nsrcc.org.tw/>), 139

#### *Taipei*

AS (Academia Sinica | <http://www.sinica.edu.tw/>), 179

ASGCC (Academia Sinica Grid Computing Centre | <http://www.sinica.edu.tw/>), 172

IP AS (Institute of Physics of the Academia Sinica | <http://www.phys.sinica.edu.tw/>), 24

NTU (National Taiwan University | <http://www.ntu.edu.tw/>), 19, 60

### **Tajikistan**

#### *Dushanbe*

ICChem ASRT (V.I.Nikitin Institute of Chemistry of the Academy of Sciences of the Republic of Tajikistan | <http://www.phti.tj/>), 139

PHTI ASRT (S.U.Umarov Physical-Technical Institute of the Academy of Sciences of the Republic of Tajikistan | <http://www.phti.tj/>), 92, 179

TNU (Tajik State University | <http://tnu.tj/>), 179

#### *Khujent*

KSU (Khujent State University | <http://www.hgu.tj/>), 179

### **Thailand**

#### *Hat Yai*

PSU (Prince of Songkla University | <http://www.psu.ac.th/>), 129

## Turkey

### *Adana*

CU (Çukurova University |  
<http://www.cu.edu.tr/>), 60

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METU (Middle East Technical University |  
<http://www.metu.edu.tr/>), 45, 60

### *Istanbul*

BU (Boğaziçi University |  
<http://www.boun.edu.tr/>), 29, 32

### *Izmir*

IZTECH (Izmir Institute of Technology |  
<http://www.iyte.edu.tr/>), 29

### *Çanakkale*

ÇOMU (Çanakkale Onsekiz Mart University |  
<http://www.comu.edu.tr/>), 129

## USA

### *Ames, IA*

ISU (Iowa State University |  
<http://www.iastate.edu/>), 60

### *Argonne, IL*

ANL (Argonne National Laboratory |  
<http://www.anl.gov/>), 112, 179

### *Arlington, TX*

UTA (University of Texas Arlington |  
<http://www.uta.edu/>), 172

### *Athens, AL*

ASU (Athens State University |  
<http://www.athens.edu/>), 160

### *Austin, TX*

UT (University of Texas at Austin |  
<http://www.utexas.edu/>), 116

### *Baltimore, MD*

JHU (Johns Hopkins University |  
<http://www.jhu.edu/>), 29, 33, 60

### *Batavia, IL*

Fermilab (Fermi National Accelerator  
Laboratory | <http://www.fnal.gov/>), 42, 45,  
60, 79, 83, 172

### *Berkeley, CA*

Berkeley Lab (Lawrence Berkeley National  
Laboratory of the University of California |  
<http://www.lbl.gov/>), 92, 95

### *Blacksburg, VA*

Virginia Tech (Virginia Polytechnic Institute  
and State University; Institute for High  
Energy Physics | <http://www.vt.edu/>), 60

### *Bloomington, IN*

IU (Indiana University Bloomington |  
<http://www.iub.edu/>), 95

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BU (Boston University |  
<http://www.bu.edu/>), 55, 60

NU (Northeastern University |  
<http://www.northeastern.edu/>), 60

### *Cambridge, MA*

Harvard Univ. (Harvard University |  
<http://www.harvard.edu/>), 45

MIT (Massachusetts Institute of Technology |  
<http://web.mit.edu/>), 60

### *Charlottesville, VA*

UVa (University of Virginia |  
<http://www.virginia.edu/>), 42, 120

### *Chicago, IL*

UChicago (University of Chicago |  
<http://www.uchicago.edu/>), 55

UIC (University of Illinois at Chicago |  
<http://www.uic.edu/>), 60

### *Cincinnati, OH*

UC (University of Cincinnati |  
<http://www.uc.edu/>), 29, 33

### *College Park, MD*

UMD (University of Maryland |  
<http://www.umd.edu/>), 14, 29, 33, 60

### *College Station, TX*

Texas A&M (Texas A&M University |  
<http://www.tamu.edu/>), 107, 112

### *Columbus, OH*

OSU (Ohio State University |  
<http://www.osu.edu/>), 60, 98

### *Coral Gables, FL*

UM (University of Miami |  
<http://welcome.miami.edu/>), 29, 33

### *Davis, CA*

UCDavis (University of California |  
<http://ucdavis.edu/>), 60

### *Durham, NC*

Duke (Duke University |  
<http://www.duke.edu/>), 129

### *East Lansing, MI*

MSU (Michigan State University |  
<http://www.msu.edu/>), 112

### *Evanston, IL*

NU (Northwestern University |  
<http://www.northwestern.edu/>), 60

### *Fairfax, VA*

GMU (George Mason University |  
<http://www.gmu.edu/>), 55

### *Gainesville, FL*

UF (University of Florida |  
<http://www.ufl.edu/>), 60

### *Gettysburg, PA*

GC (Gettysburg College |  
<http://www.gettysburg.edu/>), 129

### *Houston, TX*

Rice Univ. (Rice University |  
<http://www.rice.edu/>), 60

### *Indianapolis, IN*

IUPUI (Indiana University - Purdue  
University Indianapolis |

<http://www.iupui.edu/>), 45, 143  
*Iowa City, IA*  
 UIowa (University of Iowa | <http://www.uiowa.edu/>), 60, 92  
*Irvine, CA*  
 UCI (University of California, Irvine | <http://www.uci.edu/>), 116  
*Kingston, RI*  
 URI (University of Rhode Island | <http://ww2.uri.edu/>), 129  
*Knoxville, TN*  
 UTK (University of Tennessee of Knoxville | <http://www.utk.edu/>), 153  
*Lansing, MI*  
 IONETIX (Ionetix Corporation | <http://ionetic.com/>), 122  
*Lemont, IL*  
 ANL (Argonne National Laboratory | <http://www.anl.gov/>), 14, 19, 40, 95  
*Lexington, KY*  
 UK (University of Kentucky | <http://www.uky.edu/>), 42  
*Lincoln, NE*  
 UNL (University of Nebraska-Lincoln | <http://www.unl.edu/>), 60  
*Livermore, CA*  
 LLNL (Lawrence Livermore National Laboratory | <http://www.llnl.gov/>), 60, 107, 112  
*Los Alamos, NM*  
 LANL (Los Alamos National Laboratory; Meson Physics Facility (LAMPF) | <http://www.lanl.gov/>), 19, 60, 129  
*Los Angeles, CA*  
 UCLA (University of California, Los Angeles | <http://www.universityofcalifornia.edu/>), 60  
*Louisville, KY*  
 UofL (University of Louisville | <http://louisville.edu/>), 24  
*Lubbock, TX*  
 TTU (Texas Tech University | <http://www.ttu.edu/>), 60  
*Madison, WI*  
 UW-Madison (University of Wisconsin-Madison | <http://www.wisc.edu/>), 60  
*Menlo Park, CA*  
 SLAC (SLAC National Accelerator Laboratory is Operated by Stanford University | <http://www6.slac.stanford.edu/>), 55  
*Merced, CA*  
 UCMerced (University of California, Merced Madison | <http://www.ucmerced.edu/>), 55  
*Minneapolis, MN*  
 U of M (University of Minnesota | <http://twin-cities.umn.edu/>), 14, 29, 33, 60  
*Nashville, TN*  
 VU (Vanderbilt University | <http://www.vanderbilt.edu/>), 107, 112  
*New Haven, CT*  
 Yale Univ. (Yale University | <http://www.yale.edu/>), 95  
*New York, NY*  
 CUNY (City University of New York | <http://www.cuny.edu/>), 14, 24, 29, 33  
 RU (Rockefeller University | <http://www.rockefeller.edu/>), 14, 29  
 SUNY (State University of New York | <http://www.suny.edu/>), 29, 33  
*Newport News, VA*  
 JLab (Thomas Jefferson National Accelerator Facility; Southeastern Universities Research Association (SURA) | <http://www.jlab.org/>), 14, 33, 87  
*Norfolk, VA*  
 NSU (Norfolk State University | <http://www.nsu.edu/>), 87, 92  
*Norman, OK*  
 OU (University of Oklahoma | <http://www.ou.edu/>), 14, 29  
*Notre Dame, IN*  
 ND (University of Notre Dame | <http://www.nd.edu/>), 19, 60  
*Oak Ridge, TN*  
 ORNL (Oak Ridge National Laboratory | <http://www.ornl.gov/>), 98, 107, 112, 129, 153  
*Oxford, MS*  
 UM (University of Mississippi | <http://www.olemiss.edu/>), 60  
*Pasadena, CA*  
 Caltech (California Institute of Technology | <http://www.caltech.edu/>), 60  
*Philadelphia, PA*  
 Penn (University of Pennsylvania | <http://www.upenn.edu/>), 14, 29, 33  
*Piscataway, NJ*  
 Rutgers (Rutgers University-State University of New Jersey | <http://www.rutgers.edu/>), 29, 33, 61  
*Pittsburgh, PA*  
 CMU (Carnegie Mellon University | <http://www.cmu.edu/>), 61  
 Pitt (University of Pittsburgh | <http://www.pitt.edu/>), 120  
*Princeton, NJ*  
 PU (Princeton University; Joseph Henry Laboratories of Physics |

<http://www.princeton.edu/>), 61  
*Riverside, CA*  
 UCR (University of California, Riverside | <http://www.ucr.edu/>), 61  
*Rochester, NY*  
 UR (University of Rochester | <http://www.rochester.edu/>), 24, 29, 33, 61  
*Salt Lake City, UT*  
 U of U (University of Utah | <http://www.utah.edu/>), 33  
*Stanford, CA*  
 SU (Stanford University | <http://stanford.edu/>), 153, 179  
*Stony Brook, NY*  
 SUNY (State University of New York at Stony Brook | <http://www.stonybrook.edu/>), 79  
*Tallahassee, FL*  
 FSU (Florida State University | <http://www.fsu.edu/>), 24, 61  
*Tucson, AZ*  
 UA (University of Arizona | <http://www.arizona.edu/>), 120  
*Tuscaloosa, AA*  
 UA (University of Alabama | <http://www.ua.edu/>), 61  
*University Park, PA*  
 Penn State (Pennsylvania State University | <http://www.psu.edu/>), 14, 19, 95  
*Upton, NY*  
 BNL (Brookhaven National Laboratory | <http://www.bnl.gov/>), 55, 79, 83, 87, 92, 95, 172, 187  
*Urbana, IL*  
 I (University of Illinois at Urbana-Champaign | <http://illinois.edu/>), 65  
*Williamsburg, VA*  
 W&M (College of William & Mary | <http://www.wm.edu/>), 87, 92

## Ukraine

*Dnepropetrovsk*  
 DNU (Dnepropetrovsk National University | <http://www.dnu.dp.ua/>), 13  
*Donetsk*  
 DonIPE (Donetsk Institute for Physics and Engineering named after O.O.Galkin | <http://www.donfti.ru/main>), 129, 139  
 DonNU (Donetsk National University | <http://www.donnu.edu.ua/>), 139, 149  
*Kharkov*  
 IERT NASU (Institute of Electrophysics and Radiation Technology of the National Academy of Sciences of Ukraine | <http://www.iert.kharkov.ua/>), 83, 139, 153, 165

ISC NASU (Institute for Single Crystals of the National Academy of Sciences of Ukraine | <http://www.isc.kharkov.ua/>), 60, 116  
 ISMA NASU (Institute for Scintillation Materials of the National Academy of Sciences of Ukraine | <http://www.isma.kharkov.ua/>), 42, 65, 129, 165  
 KFTI (National Science Centre - Kharkov Institute of Physics and Technology | <http://www.kipt.kharkov.ua/>), 13, 24, 29, 60, 79, 87, 98, 101, 129, 139, 172  
 KhNU (V.N.Karasin Kharkov National University | <http://www.univer.kharkov.ua/>), 60, 79  
 LTU ("LED, Technologies Ukraine | <http://LTU.ua/>), 79

## Kiev

BITP NASU (M.M.Boholubov Institute for Theoretical Physics of the National Academy of Sciences of Ukraine | <http://www.bitp.kiev.ua/>), 13, 19, 29, 32, 50, 53, 68, 79, 98, 172, 186  
 IMP NASU (G.V.Kurdyumov Institute of Metal Physics of the National Academy of Sciences of Ukraine | <http://www.imp.kiev.ua/>), 24  
 IPMS NASU (Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine | <http://www.materials.kiev.ua/>), 139  
 ISC NASU (Chuiko Institute of Surface Chemistry of the National Academy of Sciences of Ukraine | <http://www.isc.gov.ua/>), 139  
 KINR NASU (Kiev Institute for Nuclear Research of the National Academy of Sciences of Ukraine | <http://www.kinr.kiev.ua/>), 19, 107, 112, 116, 129  
 NUK (Taras Shevchenko National University of Kyiv | <http://univ.kiev.ua/>), 24, 129, 139, 187  
 PEWI NASU (Paton Electric Welding Institute of Surface Chemistry of the National Academy of Sciences of Ukraine | <http://paton.kiev.ua/>), 83  
*L'viv*  
 IAPMM NASU (Pidstryhach Institute for Applied Problems of Mechanics and Mathematics of the National Academy of Sciences of Ukraine | <http://www.iapmm.lviv.ua/>), 13  
 ICMP NASU (Institute for Condensed Matter Physics of the National Academy of Sciences

of Ukraine | <http://www.icmp.lviv.ua/>), 24  
IFNU (Ivan Franko National University in L'viv | <http://lnu.edu.ua/>), 14  
LPNU (National University L'viv Polytechnic | <http://lp.edu.ua/>), 146

#### *Lutsk*

VNU (Volyn National University of Lesya Ukrainka | <http://www.vnu.edu.ua/>), 13

#### *Sumy*

IAP NASU (Institute of Applied Physics of the National Academy of Sciences of Ukraine | <http://iap.sumy.org/>), 129  
SumSU (Sumy State University | <http://sumdu.edu.ua/>), 14

#### *Uzhgorod*

IEP NASU (Institute of Electron Physics of the National Academy of Sciences of Ukraine | <http://www.iep.uzhgorod.ua/>), 129  
UNU (Uzhgorod National University | <http://www.uzhnu.edu.ua/>), 101

### **United Kingdom**

#### *Birmingham*

Univ. (University of Birmingham | <http://www.birmingham.ac.uk/>), 55, 98

#### *Bristol*

Univ. (University of Bristol | <http://www.bris.ac.uk/>), 55, 60

#### *Buckingham*

UB (University of Buckingham | <http://www.buckingham.ac.uk/>), 160

#### *Cambridge*

Univ. (University of Cambridge | <http://www.cam.ac.uk/>), 29, 33

#### *Canterbury*

Univ. (University of Kent | <http://www.kent.ac.uk/>), 13

#### *Didcot*

RAL (Rutherford Appleton Laboratory; Science and Technology Facilities Council | <http://www.stfc.ac.uk/>), 60, 140, 143, 146

#### *Durham*

Univ. (Durham University | <http://www.dur.ac.uk/>), 29, 33

#### *Glasgow*

U of G (University of Glasgow | <http://www.gla.ac.uk/>), 87  
US (University of Strathclyde of Glasgow | <http://www.strath.ac.uk/>), 55

#### *Liverpool*

Univ. (University of Liverpool | <http://www.liv.ac.uk/>), 29, 55, 65

#### *London*

Imperial College (Imperial College London | <http://www.imperial.ac.uk/>), 13, 29, 32, 60

Middlesex Univ. (Middlesex University | <http://www.mdx.ac.uk/>), 153  
QM (Queen Mary of the University of London | <http://www.qmul.ac.uk/>), 13  
UCL (University College London | <http://www.ucl.ac.uk/>), 116

#### *Manchester*

UoM (University of Manchester | <http://www.manchester.edu/>), 112, 116

#### *Oxford*

JAI (John Adams Institute for Accelerator Science | <http://www.adams-institute.ac.uk/>), 83

#### *Southampton*

Univ. (University of Southampton | <http://www.soton.ac.uk/>), 29, 33

#### *York*

Univ. (University of York | <http://www.york.ac.uk/>), 29, 33

### **Uzbekistan**

#### *Jizakh*

JSPI (Jizakh State Pedagogical Institute named after A.Kadri | <http://jspi.uz/>), 53, 92

#### *Samarkand*

SSU (Samarkand State University named after Alisher Navoi | <http://www.samdu.uz/>), 40, 53, 92, 107, 116

#### *Tashkent*

Assoc.“P.-S.” PTI (Physical Technical Institute Association “Physics-Sun” named after S.A.Azimov of the Academy of Sciences of the Republic of Uzbekistan | <http://uzcinet.uz/>), 19, 24, 87, 92

IAP NUU (Institute of Applied Physics of the National University of Uzbekistan named after Mirzo Ulugbek | <http://nuu.uz/>), 14, 19, 116

INP AS RUz (Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan | <http://www.inp.uz/>), 19, 61, 87, 116, 122, 140

NUU (National University of Uzbekistan named after Mirzo Ulugbek | <http://nuu.uz/>), 14

### **Vietnam**

#### *Da Nang*

DTU (Duy Tan University | <http://daytan.edu.vn/>), 140

#### *Hanoi*

IMS VAST (Institute of Material Science of the Vietnam Academy of Science and Technology | <http://ims.vast.ac.vn/>), 24

IOP VAST (Institute of Physics of the  
Vietnam Academy of Science and  
Technology | <http://www.iop.vast.ac.vn/>),  
14, 33, 112, 129, 140, 153  
VNU (Vietnam National University Hanoi |  
<http://www.vnu.edu.vn/>), 129, 179

## **CERN**

*Geneva*

CERN (European Organization for Nuclear  
Research (Switzerland) |  
<http://public.web.cern.ch/>), 11, 27, 31, 40,  
47, 55, 58, 64, 78, 82, 86, 91, 97, 106, 110,  
126, 164, 171, 178, 186

## **ICTP**

*Trieste*

ICTP (Abdus Salam International Centre for  
Theoretical Physics (Italy) |  
<http://www.ictp.it/>), 12, 28