TOPICAL PLAN
FOR JINR RESEARCH
AND INTERNATIONAL COOPERATION
2019

Dubna 2018

Contents

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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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* 01 - Theoretical Physics
02 - Elementary Particle Physics and Relativistic Nuclear Physics
03 - Nuclear Physics
04 - Condensed Matter Physics and Radiobiological Research
05 - Networking, Computing, Computational Physics
06 - Educational Programme

** 0 - All-Institute Topics
1 - Veksler and Baldin Laboratory of High Energy Physics (VBLHEP)
2 - Dzhelepov Laboratory of Nuclear Problems (DLNP)
3 - Bogoliubov Laboratory of Theoretical Physics (BLTP)
4 - Frank Laboratory of Neutron Physics (FLNP)
5 - Flerov Laboratory of Nuclear Reactions (FLNR)
6 - Laboratory of Information Technologies (LIT)
8 - Science Organization Department (SOD)
9 - Laboratory of Radiation Biology (LRB)

Theoretical Physics (01)

01–3–1135–2019/2023	Priority: 1
	Status: New

Fundamental Interactions of Fields and Particles

Leaders: D.I. Kazakov
O.V. Teryaev

Participating countries and international organizations:

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

Issues addressed and main goals of research:

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 and theoretical support of NICA/SPD program.

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 NICA/MPD program .

Theoretical support of a wide range of current and future experiments at JINR, IHEP, CERN, GSI, JLab and other physics centers.

Expected major results in the current year:

- Study of uncertainties related with the chiral structure of interactions in the Standard Model in the calculations of four-loop beta-functions of the gauge coupling constants.

  Investigation of the possibility of explanation of the Higgs decay to a $\mu - \tau$ lepton pair in the framework of supersymmetric extensions of the Standard Model.

  Analysis of the parameter space in supersymmetric and non-supersymmetric models in order to find regions where the enhancement of the rare Standard Model processes rate takes place.

  Formulation of the generalized renormalization group using the $N = 1$ $D = 8$ supersymmetric theory as an example.

  Investigation of the six-dimensional conformal supersymmetric theories and derivation of the factorization formula for the chiral amplitudes.

  Construction of the self-consistent models of the Dark Matter characterised by the spin of the Dark Matter particles and the spin of the force carriers, taking into account all possible renormalizable interactions.

  Study of the hadronic contributions to precise Standard Model observables in the framework of the dispersive approach to QCD.

  Development of approaches that increase the efficiency of calculations of the one-dimensional and two-dimensional Mellin-Barnes integrals, using approximations for the exact contours of the stationary phase.

  Development of computational techniques for the solution of multiloop Baxter equations entering Quantum Spectral Curve (QSC) formulations of different models for arbitrary operator spin values. The use of the

latter to obtain predictions for anomalous dimensions of twist 1 and 2 operators at the level not accessible by presently available techniques.

Development of computational tools for the evaluation of master integrals containing the elliptic structure. The use of the latter for the calculation of master integrals entering 2-loop single quarkonium production at LHC as well as 2-loop on-shell and off-shell (reggeon) amplitudes with an arbitrary number of legs in the $N = 4$ supersymmetric Yang-Mills theory.

Investigation of the Q^2 evolution of average multiplicities in the first two orders of perturbation theory with the double-logarithm resummation taken into account.

Consideration of the Q^2 evolution of the structure function F_2 and its derivations at small x in the first three orders of perturbation theory with BFKL corrections taken into account.

Study of the high-energy cosmic neutrinos as unique messengers of physics of and beyond the Standard Model. The observations of TeV-PeV neutrino events in the IceCube Observatory may open up windows to demonstrate the astrophysical origin of high energy neutrinos and their production mechanisms in Beyond the Standard Model scenarios.

Computer simulation of the detectability of the resonance from Higgs Δ^0, Δ^+ and Δ^{++} particles arisen from left-right symmetric extension models in the light of the proposed upgrade of IceCube Neutrino Observatory. Study of the effect of mixing of sterile neutrinos with active ones ν_e, ν_μ and ν_τ in the light of the expected data of the upgraded of IceCube Neutrino Observatory.

- Unification of Generalized Parton Distributions (GPDs) of nucleons and mesons. Investigation of GPDs dependence on transverse momentum with allowance for to two-photon corrections. Investigation of the process of $^{+-}$ -annihilation and tau-lepton decay with production of three mesons in the final state. Classical and quantum description of interaction of twisted particles with external fields. Investigation of the spin distribution and fragmentation function with the use of truncated Mellin moments formalism.

  Calculation of the coefficient function of $\gamma^*\gamma^* \to \pi^0$ hard process at QCD NNLO.

  Development of HYPERDIRE package for differential reduction of hypergeometric function with an arbitrary number of arguments, studies of analytic properties of their expansion near the rational values of parameters.

  Theoretical calculations of the signal and background in a new experiment on the search for light vector boson with a secondary muon beam, planned on the basis of NA64.

  Calculate to NLO QCD accuracy and up to all twist contributions, the transition form factors related to the pion-nucleon collision with producing the photon and nucleon, and the nucleon form factors based on the axial interpolation current within the light-cone sum rules;

  Calculations of exclusive Drell-Yan cross sections at NICA energies with taking into account of the quark-gluon and quark-quark contributions.

  Investigations of hadron energy-momentum tensor components in various QCD non-perturbative functions and their relations with the pressure in hadrons.

- Dileptonic spectrum in a rare decay of B_s-meson, $B_s \to \gamma\, \ell^+\ell^-$, induced by neutral currents with a change of flavor, will be calculated and analyzed. The corresponding form-factors of transitions will be calculated in the covariant quark model.

  Contribution to the anomalous magnetic moment of a muon due to the hadronic light-by-light scatter-ing in the leading and next-to-leading orders in the $1/N_c$ parameter will be calculated. Contribution of light mesons into the hyperfine structure of muonic hydrogen will be obtained.

  Properties of axial-vector mesons f_1, a_1 and K_1 in the ground and radially excited states will be studied, as well as their strong and electromagnetic decays and production in e^+e^- colliding beams and decays of tau-lepton.

  Masses and decay constants of exotic glueballs within the QCD sum rules will be obtained. Dynamics of glueballs with the use of the strong coupling expansion of the SU(3) Yang-Mills Hamiltonian in the flux-tube gauge will be studied. Multiquark hadrons and the existence of extraordinary dibayons will be studied.

Two-loop contributions to the Moeller scattering and the Drell-Yan processes will be calculated within the frames of the Standard Model will be calculated. Estimate of radiative corrections in proton-antiproton annihilation into a lepton pair and a pair of mesons for the PANDA facility.

A numerical method for calculating the Feynman one-loop self-energy diagram for a bound electron in the two-center problem in the Furry representation will be developed.

Systematic study of the contributions due to intermediate excited scalar, vector, and axial-vector meson states in low-energy electron-positron annihilation and tau lepton decays. Elaboration of theoretical predictions for the physical program of the Super Charm-Tau Factory in Novosibirsk.

Calculation of electroweak radiative corrections to processes which will be studied at the future high-energy electron-positron colliders with polarized beams. Participation in the theoretical analysis of the LHC Run-II data on high-precision tests of the Standard Model.

QCD analysis of new experimental data from LHC and other facilities on polarized and unpolarized nucleon structure and fragmentation functions.

Studies of phase transitions and other properties of the hadronic matter in compact stars with the help off effective low-energy QCD models.

Calculation of various light-meson contributions to the hyperfine structure of muonic hydrogen, the muon anomalous magnetic moment, and other observables measured with a high precision.

Studies pertaining to the QCD vacuum and QCD phase diagram (also in the presence of a strong magnetic field): the role of strangeness and multiquark interactions in the characteristics of the low lying meson nonets, in the freeze-out region of relativistic heavy-ion experiments, in the position of the critical end point, and in the regime of dense matter relevant for compact stars.

Studies of the high-density equations of state and mass-radius observations for compact stars and multi-polytrope approach to a strong first-order phase transition that produces high-mass twin stars as an observable signature of it.

- Study of the properties of superdense baryon matter through lattice simulation of two-color QCD with the nonzero chemical potential. Calculation of the baryon density, diquark condensate and chiral condensate and their dependence on the chemical potential.

  Lattice simulation and study of QCD at the nonzero density and magnetic field. Study of the equation of state of dense quark-gluon plasma in the magnetic field.

  Study of transport coefficients of quark-gluon plasma within lattice simulation. Calculation of the electric conductivity and temperature dependence within lattice simulation of QCD with 2+1 dynamical quarks.

  Investigation of the quark deconfinement and chiral symmetry restoration at finite temperature in the presence of the strong electromagnetic field within the Lattice QCD with overlap fermions, in particular, a catalysing role of the electromagnetic field for deconfinement. The impact of the strong electromagnetic field on monopoles and instantons will be investigated in detail.

  Participation (continuation) in the tmfT Collaboration (finite temperature with twisted mass fermions in lattice QCD) aimed at description of the quark-gluon thermodynamics including strange and charmed quarks and consideration of new observables indicating the crossover. Study of the properties of the Quark Gluon Plasma using Lattice QCD Computations using twisted mass fermions (temperature dependence of topological susceptibility and topological structure, gluon propagators and spectral functions, localization, mobility and nature of chiral symmetry restoration).

  Study of particle number fluctuations and fluctuations of the isosipn composition in hot and dense interacting pion gas in the grand canonical and canonical descriptions with the allowance for the finiteness of the system.

  Investigation of the Bose-Einstein condensation in the nonideal pion gas with a dynamically fixed number of particles.

  Study of particle production in heavy-ion collisions using the hybrid hydrodynamical model and transport models (HSD, PHSD) with an emphasis on spin dependent observables. Polarization observables for doubly strange particles will be investigated.

Calculation of neutrino production rates in neutron star medium including in-medium changes of nucleon properties and the nucleon-nucleon interaction in various approaches.

Study of the role of viscosity effects at the hydrodynamic stage of the system evolution for the multiplicity of created particles and the transverse momentum spectra, rapidity distributions as well as transverse momentum spectra of identified hadrons produced in the NICA energy range.

Analytical calculation (continuation) of the ultrarelativistic transverse momentum distributions for the Tsallis-3 and Renyi statistics.

Study of the confining properties of the statistical ensemble of domain wall networks representing nonperturbative QCD vacuum using the methods of analytical and numerical multidimensional integration.

Investigation of the impact of the long and intermediate range collective chromomagnetic fields on the direct photons and dilepton production in relativistic heavy ion collisions.

- Study of ionization of atoms in beta-decay for the energies of the knocked out electrons, comparable to the energies of ionization of atoms (about 10 eV). Study of the charge distribution of the final atoms and consideration in detail of the atomic shell effects for the MUNU and GEMMA experiments.

  The first forbidden beta decay of certain nuclei of interest will be calculated for the interpretation of data taken from SuperNEMO, CUORE, etc. Uncertainties in the spectrum of reactor neutrinos will be revised with account taken of the first forbidden beta decays of nuclei.

  The global statistical analysis of the data on exclusive and inclusive interactions of neutrino and antineutrino with nuclei at intermediate and high energies, including the most recent results of the experiments MiniBooNE, MINERvA, T2K, MicroBooNE, NOvA etc. will be continued.

  Investigation of the process of radiation of a neutrino pair that allows one to observe the violation of the conservation of L in electronic shells using laser spectroscopy methods.

  Features of the flavor neutrino transitions at short macroscopic distances will be investigated. This regime is caused by the off-shell behavior of the neutrino propagator; it arises in a covariant field-theoretical theory of neutrino oscillations and has no analogue in the standard quantum-mechanical approach. Possible experimental manifestation of this unusual regime of the neutrino oscillations will be discussed.

  Our work on optimization of the Monte Carlo neutrino generator GENIE – the most popular tool for modeling and data processing used by essentially all current accelerator experiments on neutrino interactions with matter will be continued. The work on the detailed User Guide for the 3.0.0 release of the GENIE package is planned to be accomplished.

List of activities:

Activity or experiment **Laboratory or other Division of JINR**	**Leaders** **Main researchers**
1. **Quantum field theory and physics beyond the Standard Model**	**D.I. Kazakov** **A.V. Gladyshev** **A.V. Bednyakov**
BLTP	A.N. Baushev, A.T. Borlakov, Ch.R. Das, V. Gnatich, A.V. Kotikov, G.A. Kozlov, L. Mizhishin, V.A. Naumov, A.V. Nesterenko, A.I. Onishenko, A.F. Pikelner, R. Remetsky, D.M. Tolkachev, S.I. Vinitsky, A.A. Vladimirov, R.M. Yakhibbaev, 5 students
LIT	V.P. Gerdt, O.V. Tarasov
DLNP	V.A. Bednyakov, Yu.A. Budagov, E.V. Hramov, L.V. Kalinovskaya, L.G. Tkachev, E.V. Yakushev

2.	**QCD parton distributions for modern and future colliders**	**I.V. Anikin** **O.V. Teryaev**
	BLTP	V.V. Byt'yev, M. Deka,, A.V. Efremov, S.V. Goloskokov, D.B. Kotlorz, Y.A. Klopot, S.V. Mikhailov, A.A. Pivovarov, G.Yu. Prokhorov, A.G. Oganesyan, O.V. Selyugin, A.J.Silenko, N.I. Volchanskiy, 6 students
	VBLHEP	Yu.I. Ivanshin, A.P. Nagaitsev, I.A. Savin, R. Tsenov
	DLNP	A.V. Guskov
3.	**Strong interactions phenomenology and precision physics**	**M.A. Ivanov** **V.I. Korobov** **A.E. Dorokhov**
	BLTP	A.B, Arbuzov, D. Alvarez, A.K. Bekbaev, Yu.M. Bystritsky, S.M. Eliseev, C. Ganbold, S.B. Gerasimov, A.N. Isadykov, L. Martynovich, K. Nurlan, H.-P. Pavel, A.A. Osipov, A.V. Sidorov, Yu.S. Surovtsev, Zh. Tyulemisov, M.K. Volkov, S.A. Zhaugasheva, 5 students
4.	**Theory of Hadronic Matter under extreme conditions**	**D. Blaschke** **V.V. Braguta** **E.E. Kolomeitsev** **S.N. Nedelko**
	BLTP	D.E. Alvarez-Castillo, N.Yu. Astrakhantsev, T. Bhattacharyya, M. Deka, S. Dorkin, A.E. Dorokhov, A.V. Friesen, A.A. Golubtsova, M. Hnatic, M. Hasegawa, Yu.B. Ivanov, E.-M. Ilgenfritz, L. Kaptari, A.S. Khvorostukhin, A.Yu. Kotov, K. Maslov, V,S, Melezhik, A.V. Nikolsky, S. Pandiat, A. Parvan, A.M. Snigirev, V.D. Tainov, O.V. Teryaev, V.D. Toneev, V.E. Voronin, D. Voskresensky, G.M. Zinoviev, 4 students
	LIT	A.S. Ayriyan, H. Grigorian, Yu.L. Kalinovsky, E.G. Nikonov
	VBLHEP	O.V. Rogachevsky, V. Voronyuk
5.	**Theory of electroweak interactions and neutrino physics**	**A.B. Arbuzov** **V.A. Naumov** **F. Simkovic**
	BLTP	A. Babic, A.V. Bednyakov, Yu.M. Bystritskiy, V.V. Byt'yev, A.E. Dorokhov, M.I. Krivoruchenko, K.S. Kuzmin, A.F. Pikel'ner, D.S. Shkirmanov, G. Seylkhanova, I.A. Sokal'skiy, 1 student
	VBLHE	I,D. Kakorin, V.A. Zykunov
	DLNP	Ye.V. Dydyshko, L.V. Kalinovskaya, D.V. Naumov, O.N. Petrova, R.R. Sadykov, A.A. Sapronov, O.Yu. Smirnov, V.I. Tretyak, 2 students

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL
		RAU
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	BSU
		INP BSU
		IP NASB
		JIPNR-Sosny NASB
	Gomel	GSTU
		GSU
Bulgaria	Sofia	INRNE BAS
		SU
Canada	Corner Brook	MUN
	Montreal	UdeM
CERN	Geneva	CERN
Chile	Valparaiso	UV
China	Beijing	PKU
	Lanzhou	IMP CAS
	Wuhan	WIPM CAS
Czech Republic	Prague	CTU
		CU
		IP CAS
	Řež	NPI CAS
Finland	Helsinki	UH
France	Lyon	UCBL
	Metz	UPV-M
	Montpellier	UM2
	Paris	UPMC
	Saclay	IRFU
		SPhN CEA DAPNIA
Georgia	Tbilisi	RMI TSU
		TSU
Germany	Berlin	FU Berlin
		HU
	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
	Mainz	HIM
		JGU
	Munich	LMU
	Regensburg	UR
	Rostock	Univ.
	Tübingen	Univ.
	Wuppertal	UW
	Zeuthen	DESY
Hungary	Budapest	ELTE
		Wigner RCP
ICTP	Trieste	ICTP
Italy	Naples	INFN
	Padua	UniPd
	Pavia	INFN
	Pisa	INFN
	Trieste	SISSA/ISAS
	Turin	UniTo
Japan	Tokyo	Tokyo Tech
		UT
	Kyoto	Kyoto Univ.
	Nagoya	Meiji Univ.
		Nagoya Univ.
	Tsukuba	KEK
Kazakhstan	Astana	BA INP
	Almaty	FAPHI
		INP
Mexico	Cuernavaca	UNAM
Mongolia	Ulaanbaatar	IPT MAS
New Zealand	Hamilton	Univ.
Norway	Trondheim	NTNU
Poland	Krakow	NINP PAS
	Kielce	JKU
	Lodz	UL
	Otwock-Swierk	NCBJ
Portugal	Coimbra	UC
Republic of Korea	Seoul	SNU
	Daegu	KNU
	Chongju	CBNU
Russia	Moscow	IBRAE
		IMM RAS

		ITEP
		LPI RAS
		MSU
		MI RAS
		PFUR
		SCC RAS
		SINP MSU
	Moscow, Troitsk	INR RAS
	Belgorod	BelSU
	Chernogolovka	LITP RAS
	Gatchina	NRC KI PNPI
	Irkutsk	ISDCT SB RAS
	Ivanovo	ISC RAS
		ISU
	Kazan	KFU
	Novosibirsk	BINP SB RAS
		IM SB RAS
	Omsk	OmSU
	Perm	PSNRU
	Protvino	IHEP
	Rostov-on-Don	SFedU
	St. Petersburg	SPbSU
		SPbSPU
	Samara	SSU
		SU
	Saratov	SSU
	Sarov	VNIIEF
	Tomsk	IHCE SB RAS
		TSU
	Tver	TvSU
	Yoshkar-Ola	VSUT
Serbia	Belgrade	Univ.
Slovakia	Bratislava	CU
		IP SAS
	Košice	IEP SAS
Spain	Santiago de Compostela	USC
	Valencia	UV
Sweden	Lund	LU
Switzerland	Bern	Uni Bern
Ukraine	Kiev	BITP NASU
	Dnepropetrovsk	DNU
	Kharkov	NSC KIPT
	Lutsk	EENU
	Lviv	IAPMM NASU
		IFNU

	Sumy	SumSU
United Kingdom	London	Imperial College
		QMUL
	Canterbury	Univ.
USA	New York, NY	CUNY
		RU
	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

01–3–1136–2019/2023	Priority: 1
	Status: New

Theory of Nuclear Systems

Leaders: N.V. Antonenko
S.N. Ershov
A.A. Dzhioev

Participating countries and international organizations:

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

Issues addressed and main goals of research:

Suggestion of new theoretical approaches for description and prediction of properties of superheavy, unstable nuclei and exotic nuclear systems, calculation of their characteristics; improvement of models for explanation of mechanisms of reactions of nuclei with particles and nuclei at low and intermediate energies; establishment of universal laws in low-dimensional small-particle systems and small-particle systems at ultra-low energies; development of the two-stage hybrid model of nuclear collisions at relativistic energies; study of nonlinear quantum processes in the interaction of photons with ultrashort high-frequency laser pulses.

Expected major results in the current year:

- Study of the role of the interaction of one- and two-phonon states in the description of the beta decay rates of ^{130}Cd on the trajectory of the r-process.

  Extension of the method of Wigner function moments by including the isovector-isoscalar coupling to study the fine structure of nuclear scissors mode.

  Systematic exploration of the selected E1 toroidal states in light nuclei within the quasiparticle random-phase-approximation with Skyrme forces.

  Investigation of the effect of tensor interaction on the rates of weak-interaction mediated processes with hot nuclei in supernova matter within the Skyrme-TQRPA self-consistent approach.

  Study of the statistical properties of the spectrum of 1^- states in Pb isotopes based on random matrix theory.

  Exploration of the isomeric states and their decay characteristics in superheavy nuclei.

- Study of the dependence of correlations between angular and mass distributions of quasi-fission products and multinucleon transfer reactions on the entrance channel in heavy ion collisions.

  Evaluation of the dynamic deformation of nuclear surface in heavy ion collisions at near-barrier energies.

  Ascertainment of the energy restrictions on the realization of a true ternary fission: sequential and simultaneous fission mechanisms.

  Investigation of the influence of charge and mass asymmetry dynamics on the widths of fission mass distributions within the DNS model.

  Study of the exchange of nucleon pairs and alpha-particle between DNS nuclei and its influence on the fusion probability by applying the master equation with the phenomenological transport coefficients.

  Study of the dissipation effect on relaxation of collective states in finite quantum systems.

- Theoretical investigation of ultracold scattering by static impurities in atomic traps.

  Proof of preserving the unconditional basis property for spectral subspaces under non-self-adjoint perturbations of self-adjoint Hamiltonians.

Development of low-energy approximation for two-dimensional scattering amplitude on a long-range potential.

Calculations of structures of hypernuclei with two Λ-hyperons and three-atom clusters He_2Be in the framework of the Faddeev equations.

Analysis of metastable and bound states of a Beryllium trimer with realistic pair interactions in a collinear configuration.

Numerical computations of cluster states and breakup of exotic nuclear systems.

Elaboration of a new analytic adiabatic expression for excitation probability of the hydrogen atom in a laser field.

- Investigation of the properties of pseudo-scalar mesons at finite temperature basing on the solutions of combined Dyson-Schwinger and Bethe-Salpeter equations.

Study of the distorted spin spectral function ^{3}He to determine the three-dimensional structure of a nucleon from generalized parton distributions in exclusive deep-inelastic processes.

Obtaining of gluon and ghost propagators from solutions of the Dyson-Schwinger equations for vertices and propagators of gluons, ghosts and quarks with effective kernels of interaction.

Elaboration of the relativistic statistical model of an expanding fireball of different topological forms on the basis of the Boltzmann-Gibbs statistics and the local equilibrium principle to describe the experimental data on transverse momentum distributions of hadrons produced in the proton-proton and heavy-ion collisions at high energies.

Detailed analysis of the Breit-Wheeler electron-positron pair production in multi-consecutive short and ultra short (sub-cycle) laser pulses with arbitrary pulse polarization and carrier phase as a probe for nonlinear multi-photon dynamics in QED.

Development of theoretical models for open heavy quark production in hadronic interaction as a probe for the reaction mechanisms and the structure of exotic hadron resonances.

Calculation of the amplitude of the process $gg \to \pi\pi$ and numerical computing of baryon masses within the three flavour Polyakov-Nambu-Jona Lasinio model.

Investigation of the electromagnetic form factors of ^{3}He in the relativistic Bethe-Salpeter-Faddeev formalism taking into account two-particle states with a nonzero orbital angular momentum.

List of activities:

Activity or experiment **Laboratory or other Division of JINR**	**Leaders** **Main researchers**
1. **Microscopic models for exotic nuclei and nuclear astrophysics**	**V.V. Voronov** **A.A. Dzhioev** **J. Kvasil**
BLTP	N.N. Arsenyev, E.B. Balbutsev, H. Ganev, V.A. Kuz'min, L.A. Malov, I.V. Molodtsova, V.O. Nesterenko, A.P. Severyukhin, V.M. Shilov, A.V. Sushkov, A.I. Vdovin, 2 students
LIT	N.Yu. Shirikova
FLNP	A.M. Sukhovoi
DLNP	V.B. Brudanin
2. **Low-energy nuclear dynamics and properties of nuclear systems**	**S.N. Ershov** **N.V. Antonenko** **R.V. Jolos**

	BLTP	G.G. Adamian, A.V. Andreev, A.N. Bezbakh, I.A. Egorova, V.G. Kartavenko, Sh. Kalandarov, A.K. Nasirov, R.G. Nazmitdinov, H. Paşca, I.S. Rogov, T.M. Shneidman, 2 students
	FLNR	L.V. Grigorenko, Yu.E. Penionzhkevich
3. **Quantum few-body systems**		**A.K. Motovilov** **A.S. Melezhik**
	BLTP	D. Janseitov, I. Ishmukhamedov, S.S. Kamalov, O.P. Klimenko, E.A. Kolganova, V.N. Kondratyev, A.A. Korobitsyn, E.A. Koval, A.V. Malykh, V.S. Melezhik, V.V. Pupyshev, E.A. Solov'ev, D. Valiolda, S.I. Vinitsky, 4 students
	DLNP	O.I. Kartavtsev
	LIT	O. Chulunbaatar, V.P. Gerdt, A.A. Gusev
4. **Relativistic nuclear dynamics and nonlinear quantum processes**		**V.V. Burov** **M. Gaidarov** **S.G.Bondarenko**
	BLTP	A.V. Frisen, L.P. Kaptari, A. Khvorostukhin, V.K. Lukyanov, E. Myrzabekova, A.S. Parvan, N. Sagimbaeva, A.I. Titov, V.D. Toneev, S.A. Yur'ev, 1 student
	LIT	K.V. Lukyanov, E.V. Zemlyanaya
	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
		YSU
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	CIAE
		ITP CAS
		PKU
Czech Republic	Prague	CU

	Řež	NPI CAS
Egypt	Cairo	EAEA
	Giza	CU
France	Bordeaux	UB
	Caen	GANIL
	Orsay	CSNSM
		IPN Orsay
Germany	Bonn	UniBonn
	Cologne	Univ.
	Darmstadt	GSI
		TU Darmstadt
	Dresden	HZDR
	Erlangen	FAU
	Hamburg	Univ.
	Frankfurt/Main	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
India	Kasaragod	CUK
	Chandigarh	PU
Iran	Zanjan	IASBS
Italy	Bologna	Centro, ENEA
	Catania	INFN LNS
	Naples	INFN
	Messina	UniMe
	Perugia	INFN
	Turin	UniTo
Japan	Kobe	Kobe Univ.
	Morioka	Iwate Univ.
	Osaka	RCNP
		Osaka Univ.
Kazakhstan	Almaty	INP
Lithuania	Kaunas	VMU
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	MSU
		NNRU "MEPhI"
		NRC KI
		PFUR
		SINP MSU
	Moscow, Troitsk	INR RAS
	Gatchina	NRC KI PNPI
	Krasnoyarsk	KIP SB RAS
	Omsk	OmSU
	Saratov	SSU
	St. Petersburg	SPbSU
	Vladivostok	FEFU
Serbia	Belgrade	IPB
Slovakia	Bratislava	CU
		IP SAS
	Košice	IEP 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
		IP AS
United Kingdom	Surrey	Univ.
Ukraine	Kiev	BITP NASU
		KINR NASU
		NUK
	Kharkov	NSC KIPT
USA	Lemont, IL	ANL
	Durham, NC	NCCU
	Los Alamos, NM	LANL
	Notre Dame, IN	ND
	University Park, PA	Penn State
Uzbekistan	Tashkent	Assoc."P.-S." PTI
		IAP NUU
		INP AS RUz

01–3–1137–2019/2023	Priority: 1
	Status: New

Theory of Complex Systems and Advanced Materials

Leaders: V.A. Osipov
A.M. Povolotskii

Participating countries and international organizations:

Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Brazil, Bulgaria, Canada, Czech Republic, Denmark, Egypt, France, Germany, Hungary, India, Iran, Ireland, Italy, Japan, Mongolia, New Zealand, Poland, Republic of Korea, Romania, Russia, Serbia, Slovakia, Slovenia, South Africa, Spain, Switzerland, Taiwan, Ukraine, USA, Uzbekistan, Vietnam.

Issues addressed and main goals of research:

Development of analytical and numerical methods for studying complex many-body systems that are of current interest in modern condensed matter physics, the development of mathematical models of these systems and the identification of universal laws on the example of studied models. Analysis of both lattice and field-theory models of equilibrium and non-equilibrium statistical systems and modeling of a wide class of new materials, including nanostructured materials, which are of great practical importance. The concepts of scaling and universality allow one to go beyond the model approach and to apply the results obtained to broad classes of phenomena studied in the physics of condensed matter. The results obtained will be used in carrying out experimental studies of condensed matter at JINR. It is important to note the markedly growing interdisciplinary nature of research, where condensed matter physics and statistical physics closely intersect with atomic and nuclear physics, particle physics, mathematical physics, astrophysics, and biology.

Expected major results in the current year:

- Investigation of strongly-correlated electron superconductivity within the t-J model on the two-dimensional honeycomb lattice: determination of the superconducting order parameter symmetry and calculation of the superconducting transition temperature.

  Model and *ab initio* calculations of magnetic and electronic band structure of rare-earth metals under high external presure.

  Structural investigations of mass and surface fractals at nano- and micro-scale using the small-angle scattering technique.

  Study of the Bose-Hubbard model with repulsive interactions and its classical limit, discrete nonlinear Schroedinger equation, at negative temperatures.

  Investigation of the possibility of regulating spin dynamics in dipolar and spinor systems by using the quadratic Zeeman effect. Development of the theory of fast magnetization reversal by influencing effective magnetic anisotropy with the help of external alternating fields.

- Investigation of the effect of strong magnetic field in changing the electronic structure of the hole-doped cuprates; revealing of the role of the superconducting fluctuations in the formation of the pseudogap Fermi surface consisting of electron-like nodal pockets.

  Study of the transport properties of Weyl-semimetal/superconductor junctions in the presence of the external magnetic field.

  Investigation of the dynamics and current-voltage characteristics of superconductor - ferromagnet - superconductor structures for superconducting spintronics. Manifestation of the Kapitza pendulum features in these structures. Development of a model “nanomagnet + stack of interinsic Josephson junctions”. Investigation of the possibility of synchronizing a system of coupled Josephson junctions under the influence of a single nanomagnet and a chain of coupled nanomagnets.

  Calculation of the density of states, conductivity and electron mobility in fluorinated graphene and phosphorene taking into account the influence of various types of defects and electron-phonon interaction.

Calculation of the concentration and temperature dependences of the electron mobility in polycrystalline graphene. Analysis of the thermoelectric transport coefficients of polycrystalline graphene.

Calculation of a conductivity of electrolyte field effect transistors based on various types of low-dimensional structures, for example carbon nanotubes, graphene nanoribbon, phosphorene, hexagonal boron nitride and their heterostructures with biomolecules-detectors, such as DNAzymes, antibodies, etc. Investigation of the influence of different concentrations of detected material on the conductivity.

Investigation of the time behavior of quantum correlations between various structural elements in a quasi-one-dimensional macromolecular structure, including their entanglement, depending on the initial vibronic excitation of the macromolecule.

- Derivation of exact expressions for the cumulants of an avalanche flow in the Raise and Peel model. Calculation of the second cumulant of the particle flow in the q-boson zero range process. Analysis of its asymptotics and construction of the function describing the KPZ - Edward-Willkinson crossover.

  Investigation of the growth of the cluster of visited sites in the model of Eulerian walkers. Characterization of the properties of the boundary of the growing cluster.

  Calculation of the probability of formation of configurations with N bridges near the boundary in the branching polymers model or spanning trees on the lattice for the isotropic and anisotropic cases.

  Finding of symmetries of elliptic hypergeometric integrals generated by Bailey lemmas mixing the A_n and C_n root systems and investigation of their consequences for superconformal indices of four-dimensional supersymmetric quantum field theories.

  Generalization and proof of the structure Cayley-Hamilton theorems for classical infinite series of the quantum matrix (super)algebras, investigation of the structure of the Cartan calculus for the linear quantum groups in detail, i.e. description of the center of the commutative subalgebras possibilities and consideration of a possibility for the SL-reduction.

  Investigation of low-energy limit of the (super)-Yang-Mills theories in 4,5,6, dimensions compactified to the circle of the small radius of the Riemann surface. Proof that the Yang-Mills theories are reduced to sigma models with target space depending on geometric conditions imposed on gauge fields.

List of activities:

Activity or experiment **Laboratory or other Division of JINR**	**Leaders** **Main researchers**
1. **Complex materials and nanostructures**	**E. Anitas** **N.M. Plakida**
BLTP	A.Yu. Cherny, A.L. Kuzemsky, Tung Nguen Dan, A.A. Vladimirov, V.I. Yukalov, V.Yu. Yushankhai
FLNP	V.L. Aksenov, A.M. Balagurov, D.P. Kozlenko, A.I. Kuklin
LIT	L.A. Syurakshina, E.P. Yukalova
2. **Complex materials and nanostructures**	**V.A. Osipov** **E.A. Kochetov**
BLTP	A.V. Chizhov, A.A. Glebov, I.D. Ivantsov, V.L. Katkov, D.V. Kolesnikov, S.E. Krasavin, K.V. Kulikov, M. Maiti, S.Yu. Medvedeva, V.N. Plechko, I.R. Rahmonov, O.G. Sadykova, Yu.M. Shukrinov, J. Smotlacha
FLNP	V.L. Aksenov, A.M. Balagurov, A.I. Kuklin
LIT	I. Sarhadov, S.I. Serdyukova, E.B. Zemlianaya
LNR	A. Olejniczak

3. **Contemporary problems of statistical physics**	**A.M. Povolotsky** **J. Brankov**	
BLTP	N.Zh. Bunzarova, A.E. Derbyshev, V.M. Dubovik, V.I. Inozemtsev, T.A. Ivanova, V. Papoyan, P.N. Pyatov, V.P. Spiridonov, P.E. Zhidkov	

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Armenia	Yerevan	Foundation ANSL
		YSU
		IIAP NAS RA
Australia	Melbourne	Univ.
	Sydney	Univ.
Austria	Vienna	TU Wien
	Linz	JKU
Azerbaijan	Baku	Branch MSU
Belarus	Minsk	BSTU
		IP NASB
		ISEI BSU
		JIPNR-Sosny NASB
		SPMRC NASB
Belgium	Louvain-la-Neuve	UCL
Brazil	Brasilia, DF	UnB
	Sao Paulo, SP	USP
	Natal, RN	IIP UFRN
Bulgaria	Sofia	IMech BAS
		INRNE BAS
		ISSP BAS
		SU
	Plovdiv	PU
Canada	Montreal	Concordia
	Quebec	UL
	Kingston	Queen's
	London	Western
Czech Republic	Řež	NPI CAS
Denmark	Lyngby	DTU
Egypt	Giza	CU
France	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
	Jena	Univ.
	Leipzig	UoC
	Magdeburg	OVGU
	Rostock	Univ.
	Wuppertal	UW
Hungary	Budapest	Wigner RCP
India	Mumbai	TIFR
	Kolkata	IACS
Iran	Zanjan	IASBS
Ireland	Dublin	DIAS
Italy	Catania	UniCT
	Salerno	UNISA
Japan	Utsunomiya	UU
Mongolia	Ulaanbaatar	NUM
New Zealand	Auckland	Univ.
Poland	Krakow	JU
	Warsaw	IPC PAS
	Wroclaw	WUT
	Katowice	US
	Poznan	AMU
		IMP PAS
Republic of Korea	Daejeon	CTPCS IBS
Romania	Bucharest	IFIN-HH
	Cluj-Napoca	UTC-N
	Timişoara	UVT
Russia	Moscow	ITEP
		MI RAS
		MIREA
		NNRU "MEPhI"
		NRC KI
		NRU HSE
		PFUR
		SINP MSU
	Moscow, Troitsk	HPPI RAS
	Belgorod	BelSU
	Gatchina	NRC KI PNPI
	Kazan	KFU
	Perm	PSNRU

	Protvino	IHEP
	Samara	SU
	Saratov	SSU
	St. Petersburg	ETU
		Ioffe Institute
		PDMI RAS
		SPbSU
	Voronezh	VSU
Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	CU
	Košice	IEP SAS
		PJSU
Slovenia	Ljubljana	UL
South Africa	Pretoria	UNISA
Spain	Madrid	ICMM-CSIC
Switzerland	Villigen	PSI
	Zurich	ETH
Taiwan	Taipei	IP AS
Ukraine	Kharkov	NSC KIPT
	Kiev	IMP NASU
		NUK
	Lviv	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

01–3–1138–2019/2023	Priority: 1
	Status: New

Modern Mathematical Physics: Gravity, Supersymmetry and Strings

Leaders: A.P. Isaev
S.O. Krivonos
A.S. Sorin

Scientific leader: A.T. Filippov

Participating countries and international organizations:

Armenia, Australia, Brazil, Bulgaria, Canada, CERN, Czech Republic, Estonia, France, Germany, Greece, ICTP, India, Israel, Iran, Ireland, Italy, Japan, Lithuania, Luxembourg, Norway, Poland, Portugal, Republic of Korea, Russia, Spain, Taiwan, Ukraine, United Kingdom, USA.

Issues addressed and main goals of research:

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 of 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 investigation and description of a variety of classical and quantum integrable models and their exact solutions; analysis of a wide range of problems in supersymmetric theories including models of superstrings and superbranes, study of non-perturbative regimes in supersymmetric gauge theories; development of cosmological models of the early Universe, primordial gravitational waves and black holes. The decisive factor in solving the above problems will be the crucial use of the mathematical methods of the theory of integrable systems, quantum groups and noncommutative geometry as well as superspace techniques.

Expected major results in the current year:

- Study of the symmetries of the space of states or Bethe vectors for different quantum integrable systems. These symmetries will be used to obtain effective formulas for the scalar products of the vectors from these spaces. The effective formulas for the scalar products allow investigation of nontrivial physical models solvable by the hierarchical Bethe Ansatz method.

  The construction and studies of the generalized (deformed) Calogero- Moser systems will be continued. In particular, the relations of the generalized KP hierarchies with the Calogero - Moser systems and their spin versions as well as the construction of classical integrable systems on quiver varieties and their quantization will be investigated.

  The development of special Bohr - Sommerfeld geometry of algebraic varieties needs to solve the main problem - construction of finite dimensional moduli spaces of stable special Bohr - Sommerfeld cycles. The main conjecture says that these moduli spaces are algebraic. The construction of the Landau - Ginzburg models on the moduli spaces of the special Bohr - Sommerfeld cycles over Fano varieties will be provided.

  Investigations of the confinement-deconfinement transportation, using exact solutions of the holographic flow of renormgroup with SL(2,C)-symmetry and AdS-fixed point will be continued including - the construction of the holographic RG flows with a couple of effective charges. Interpretation of the flows as a collection of branes in the corresponding supergravity theory; - studies of the transport coefficients of quark-gluon plasma using holographic approach in 5 dimensional Kerr - AdS solution.

Studythe relation between n-dimensional N=4 supersymmetric mechanics and the WDVV equation, generalization of the latter to curved spaces, i.e. to arbitrary Riemannian. In this curved WDVV equation, the third derivative of the pre-potential is replaced by the third-rank Codazzi tensor, while the WDVV equation itself acquires a non-trivial right-hand side given by the Riemann curvature tensor. The solutions of the curved WDVV equation have been found for metrics with a potential and on arbitrary isotropic spaces. The latter solution is built on an arbitrary solution of the flat WDVV equation. Thus, any such flat solution can be lifted to a curved solution on an isotropic space. It is planned to construct the corresponding N = 4 supersymmetric mechanics with non-trivial potentials.

Study of the boundary three-point function in the 2D conformal Liouville field theory in the semi-classical limits. In particular, we are going to address the light and heavy asymptotic limits. Since the boundary three-point function is related to the fusion matrix, full understanding of these limits gives us information on the corresponding behavior of the fusion matrix. Analysis of the boundary three-point function in the heavy asymptotic limit. This can be done by estimating the action of the Liouville theory with a boundary on solutions with the three boundary singularities. Remembering that, as was mentioned above, the boundary three-point function is related to the fusion matrix and that heavy asymptotic limit of the conformal blocks is related to the solutions of the Heun and Painleve VI equations, one can obtain in this way information on the monodromy properties of their solutions.

- Study of the structure of superfield counterterms and other invariants in N=(1,0), N=(1,1) and N=(2,0) supersymmetric gauge theories in 6 dimensions by the harmonic superspace methods. The analysis of these models in the framework of generic AdS/CFT correspondence, quantization of such theories, computing their quantum effective action and learning the full structure of admissible counter-terms. For such an analysis, of high importance is the formalism of harmonic superfields with the maximal number of manifestly realized supersymmetries.

  Investigations of multiparticle systems with extended Poincare d=1 and superconformal supersymmetries and various SU(m|n) deformed supersymmetries. These studies will be based on the construction of new models of supersymmetric mechanics by using gauging isometries of matrix superfield systems.

  Construction of new models of multiparticle mechanics with extended supersymmetry on curved spaces, investigation of the quantum properties of the constructed models, their integrability and connection with matrix models of the string theory as well as their application in nuclear physics models, elementary particle physics and high energy.

  Construction on the complex / quaternionic Euclidean and projective spaces of superintegrable analogs of known oscillator-like systems, allowing the interaction with constant magnetic / instanton field, and further supersymmetrization of them.

  Construction and study of superintegrable generalizations of generalized oscillator models (with additional Calogero-like potentials) on complex / quaternion projective spaces that interact with external magnetic constant / instanton fields, and then performing their "weak N=4 supersymmetrization". We plan to build analogues of the Smorodinsky-Winternitz and Rosokhatius systems and their "weak" N=4 supersymmetric extensions, study their symmetry algebra and classical and quantum-mechanical solutions, and extend this analysis to Calogero type systems.

  Construction of the twistor formulations of particles and superparticles of fixed spin (helicity), as well as higher spin particles.

  Investigation the properties of topological solitons in classical and quantum field theory in flat and curved space-time as well as the investigation of black holes and regular localized field configurations in the extended models of gravity coupled to the matter fields, including non-Abelian fields, will be continued.

- Owing to the birth of gravitational-wave astronomy and the acquisition of new observational data (LIGO, VIRGO, etc.), it became possible to test both various theories of modified gravity and effective models of black holes and other compact highly gravitating objects. In this regard, the following research directions are outlined: - the study of the cosmological consequences of various theories of modified gravity; - the development and study of new modified gravity theories, capable of explaining inflation and modern dark energy in a single approach; - the construction of effective models such as rotating single and double black holes and other compact objects (such as NUT solutions) in various theories of gravity; -the development of new approaches and methods of mathematical physics to the study of effective models of compact objects

in various theories of modified gravity; -the study of various boundary effects in conformal theories, such as Casimir effect, and their possible holographic description in dual gravity theories in order to comprehend the behavior of these effects in the strong coupling regime; - the calculation of the Casimir effect due to the interaction of the quantum field with another quantum field confined in the spatially non-connected regions (two half spaces, for instance) and elaboration of the methods explicitly taking this interaction into account without replacing it by effective boundary conditions; - the elaboration of spectral geometry methods (zeta functions, heat kernel expansions) for differential operators on the singular background or with singular potential, along with the development of the spectral summation method with the goal to employ it in boundary problems with matching conditions on the interfaces between different material media.

List of activities:

Activity or experiment **Laboratory or other Division of JINR**	**Leaders** **Main researchers**
1. **Quantum groups and integrable systems**	**A.P. Isaev** **N.A. Tyurin**
BLTP	M. Buresh, P. Fiziev, A.A. Golubtsova, N.Yu. Kozyrev, D.R. Petrosyan, M. Podoinitsyn, G.S. Pogosyan, A.V. Silantyev
UC	S.Z. Pakuliak
2. **Supersymmetry**	**E.A. Ivanov**
BLTP	S.A. Fedoruk, A. Nersessian, M. Pientek, A. Pietrikovsky, I.B. Samsonov, G. Sarkissyan, S.S. Sidorov, Ya.M. Shnir, A.O. Sutulin
3. **Quantum gravity, cosmology and strings**	**A.T. Filippov** **I.G. Pirozhenko** **V. Nesterenko**
BLTP	B.M. Barbashov, I. Bormotova, E.A. Davydov, V.V. Nesterenko, A.B. Pestov, A.A. Provarov, G.I. Sharygin, E.A. Tagirov, P.V. Tretyakov, P. Yaluvkova, A.F. Zakharov, 3 students
LIT	I.L. Bogoliubsky, A.M. Chervyakov
VBLHEP	E.E. Donets

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Armenia	Yerevan	YSU
Australia	Sydney	Univ.
	Perth	UWA
Brazil	Sao Paulo, SP	USP
	Juiz de Fora, MG	UFJF
	Vitoria, ES	UFES
Bulgaria	Sofia	INRNE BAS
Canada	Edmonton	U of A
CERN	Geneva	CERN

Czech Republic	Opava	SlU
	Prague	CTU
	Řež	NPI CAS
Estonia	Tartu	UT
France	Annecy-le-Vieux	LAPP
	Lyon	ENS Lyon
	Marseille	CPT
	Nantes	SUBATECH
	Paris	ENS
		LUTH
	Tours	Univ.
Germany	Bonn	UniBonn
	Hannover	LUH
	Leipzig	UoC
	Oldenburg	IPO
	Potsdam	AEI
Greece	Athens	UoA
	Thessaloniki	AUTH
ICTP	Trieste	ICTP
India	Kolkata	BNC
	Chennai	IMSc
		IACS
Israel	Tel Aviv	TAU
Iran	Tehran	IPM
Ireland	Dublin	DIAS
Italy	Trieste	SISSA/ISAS
	Frascati	INFN LNF
	Padua	UniPd
	Pisa	INFN
	Turin	UniTo
Japan	Tokyo	UT
		Keio Univ.
Lithuania	Vilnius	VU
Luxembourg	Luxembourg	Univ.
Norway	Trondheim	NTNU
Poland	Lodz	UL
	Wroclaw	UW
Portugal	Aveiro	UA
Republic of Korea	Seoul	SKKU
Russia	Moscow	ITEP
		LPI RAS
		MI RAS
		MSU
		SAI MSU
	Moscow, Troitsk	INR RAS

	Chernogolovka	LITP RAS
	Kazan	KFU
	Novosibirsk	NSU
	Protvino	IHEP
	St. Petersburg	PDMI RAS
	Tomsk	TPU
		TSPU
Spain	Bilbao	UPV/EHU
	Santiago de Compostela	USC
	Barcelona	IEEC-CSIC
	Valencia	IFIC
	Madrid	ETSIAE
Taiwan	Taoyuan City	NCU
Ukraine	Kiev	BITP NASU
	Kharkov	NSC KIPT
		KhNU
United Kingdom	London	Imperial College
	Cambridge	Univ.
	Canterbury	Univ.
	Durham	Univ.
	Glasgow	U of G
	Leeds	UL
	Nottingham	Univ.
USA	Amherst, NM	UMass
	Tempe, AZ	ASU
	New York, NY	CUNY
		SUNY
	College Park, MD	UMD
	Coral Gables, FL	UM
	Norman, OK	OU
	Piscataway, NJ	Rutgers
	Rochester, NY	UR

01–3–1117–2014/2023	Priority: 1

Status: Extended

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

Leaders: V.V. Voronov
A.S. Sorin

Scientific leader: A.T. Filippov

Participating countries and international organizations:

Armenia, Austria, Belarus, Brazil, Bulgaria, Canada, China, CERN, Czech Republic, France, Germany, Greece, Hungary, India, Israel, Italy, Japan, Norway, Poland, Romania, RSA, Russia, Serbia, Slovakia, Spain, 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 major results in the current year:

- Organization of four 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:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers
1. **DIAS-TH**	**A.S. Sorin** **V.V Voronov**
BLTP	D. Blaschke, A.V. Frizen, A.P. Isaev, M.A. Ivanov, R.V. Jolos, D.I. Kazakov, E.A. Kolganova, I.G. Pirozhenko, V.A. Osipov, V.P. Spiridonov, A.A. Starobinsky, O.V. Teryaev, P.V. Tretyakov, V.I. Zhuravlev, 4 students
LIT	V.V. Korenkov, Yu.L. Kalinovsky
UC	S.Z. Pakuliak
FLNP	V.L. Aksenov
VBLHEP	V.D. Kekelidze, M.V. Savina
DLNP	V.A. Bednyakov
FLNR	Yu.Ts. Oganessian

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	YSU
Austria	Vienna	TU Wien
		ITP TU Wien
Belarus	Gomel	GSTU
Brazil	Sao Paulo, SP	USP
Bulgaria	Sofia	INRNE BAS
		SU
Canada	Montreal	UdeM
	Edmonton	U of A
CERN	Geneva	CERN
China	Wuhan	WHU
Czech Republic	Prague	CTU
	Řež	NPI CAS
France	Annecy-le-Vieux	LAPP
	Dijon	UB
	Lyon	ENS Lyon
	Marseille	CPT
	Nantes	SUBATECH
	Paris	ENS
		LPTHE
	Valenciennes	UVHC
Germany	Bonn	UniBonn
	Zeuthen	DESY

	Hamburg	DESY
	Hannover	LUH
	Jena	Univ.
	Leipzig	UoC
	Munich	MPI-P
	Potsdam	AEI
	Rostock	Univ.
Greece	Athens	UoA
Hungary	Budapest	Wigner RCP
India	Kolkata	BNC
Israel	Rehovot	WIS
Italy	Frascati	INFN LNF
	Padua	UniPd
	Pavia	INFN
	Pisa	INFN
	Salerno	UNISA
	Trieste	SISSA/ISAS
	Turin	INFN
Japan	Kyoto	KSU
		RIMS
	Tsukuba	KEK
	Chiba	CIT
Norway	Oslo	UiO
Poland	Warsaw	UW
	Otwock-Swierk	NCBJ
	Wroclaw	UW
Romania	Bucharest	IFIN-HH
Russia	Moscow	ITEP
		NRU HSE
		MSU
		SCC RAS
		SINP MSU
		MI RAS
		VNIIMS
	Moscow, Troitsk	INR RAS
	Chernogolovka	LITP RAS
	Protvino	IHEP
	St. Petersburg	PDMI RAS
	Tomsk	TSU
	Novosibirsk	BINP SB RAS
	Saratov	SSU
Serbia	Belgrade	IPB
		Univ.
Slovakia	Banska Bistrica	UMB
Spain	Madrid	UAM

South Africa	Cape Town	UCT
Turkey	Istanbul	BU
Ukraine	Kiev	BITP NASU
United Kingdom	London	Imperial College
	Durham	Univ.
	Cambridge	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: Being concluded

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

Leader: A.S. Zhemchugov
Deputy: A.V. Guskov

Participating countries and international organizations:

CERN, China, Germany, Poland, Russia, Sweden.

Issues addressed and main goals of research:

The BES-III experiment at the electron-positron collider BEPC (IHEP CAS, Beijing, China) is aimed at systematic and precise measurements in τ-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, τ-lepton physics and search for new exotic XYZ states. Data taking started in 2009. The world largest sample of J/ψ, ψ(3686), ψ(3770), ψ(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.
The goal of ARIeL project is to develop the research program for a future e^+e^- collider. The precision of measurements is expected rto be improved by a 1-2 orders of magnitude with respect to the one at LHC. To reach a precision like this the necessary tools, both theoretical and experimental, should prepared in advance.

Expected major results in the current year:

- 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.
- Development of the multipurpose MC event generator to describe main processes of e^+e^- annihilation including radiative corrections at the level of more than one loop. The generator will take into account the particle polarization both for initial and final states.
- Development of the standart program codes to calculate the radiation corrections at the level of 2 (for EW interactions) and 3 (for strong interactions) loops.
- Study of research potential of experiments at CLIC collider in the domain of precision measurements and search of new physics in the base of full detector simulation.

List of projects:

Project	Leader	Priority (period of realization)
1. BES-III	A.S. Zhemchugov	1 (2007 – 2019)
2. ARIeL	L.Y. Kalinovskaya	3 (2019 – 2021)

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **BES-III Project**	**A.S. Zhemchugov**	Realization

DLNP	O.V. Bakina, I.R. Boyko, D.V. Dedovich, I.I. Denisenko, A.V. Guskov, S.A. Kotov, Yu.A. Nefedov, G.A. Shelkov	
BLTP	V.V. Bytev, O.V. Teryaev	
LIT	S.D. Belov, V.V. Korenkov, G.A. Ososkov, I.S. Pelevanyuk, O.I. Streltsova, V.V. Trofimov, A.V. Uzhinsky	
2. **ARIeL Project**	**L.V. Kalinovskaya**	Realization
DLNP	I.R. Boyko, E.V. Dydyshko, E.O. Lutsenko, Yu.A. Nefedov, I.I. Novikov, N.E. Pukhaeva, S.S. Rzaeva, L.A. Rumyantsev, A. Rymbekova, A.A. Sapronov, R.R. Sadykov, P.V. Shvidkin, A.S. Zhemchugov	
BLTP	A.B. Arbuzov, C.G. Bondarenko	
LIT	I.S. Pelevanyuk	

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
CERN	Geneva	CERN
China	Beijing	IHEP CAS
Germany	Hamburg	DESY
	Hannover	LUH
Poland	Krakow	NINP PAS
	Katowice	US
Russia	Gatchina	NRC KI PNPI
	Novosibirsk	BINP SB RAS
Sweden	Lund	LU

02–0–1081–2009/2019	Priority: 1

Status: Being concluded

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, Bulgaria, Canada, CERN, Czech Republic, France, Germany, Georgia, Israel, Italy, Netherlands, Russia, Slovakia, Spain, USA, Uzbekistan.

Issues addressed and main goals of research:

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 major results in the current year:

- 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, as well as development of a new detectors.
- 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 – 2020)

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	I.R. Boyko, Yu.I. Davydov, D.V. Dedovich, M.A. Demichev, A.V. Ershova, I.V. Eletskikh, V.V. Glagolev, A.L. Gongadze, I.V. Gongadze, L.A. Gongadze, M.I. Gostkin, L.K. Gladilin, N. Huseinov, Yu.P. Ivanov, S.N. Karpov, Z.M. Karpova, D.V. Kharchenko, S.A. Kotov, V.G. Kruchonok, Yu.A. Koultchitski, M.V. Lyablin, G.I. Lykasov, V.V. Lyubushkin, T.V. Lyubushkina, I.A. Minashvili, I. Minashvili (jr.), Yu.A. Nefedov, I.N. Potrap, E.M. Plotnikova, T.O. Rudenko, S.S. Rzaeva, A.A. Sapronov, A.N. Shalyugin, M.M. Shiyakova, R.V. Sotenskii, R.R. Sadykov, Yu.Yu. Stepanenko, A.A. Sapronov, P.V. Shvydkin, S.M. Turchikhin, P.V. Tereshka, Yu.A. Usov, Z.U. Usubov, V.B. Vinogradov, A.C. Zhemchugov	
VBLHEP A.P. Cheplakov	F.N. Ahmadov, N. Dzhavadov, Yu.A. Filippov, A.V. Ivanov, E.A. Ladygin, V.V. Kukhtin, B.G. Shaykhatdenov, A.A. Soloshenko, T. Turtuvshin, N.I. Zimin	
LIT V.V. Korenkov, P.V. Zrelov	I.N. Aleksandrov, N.I. Gromova, M.A. Mineev, D.A. Oleynik, A.S. Petrosyan, V.N. Shigaev, A.V. Yakovlev	
BLTP D.I. Kazakov	A.B. Arbuzov, S.G. Bondarenko, A.V. Bednyakov, A.V. Gladyshev, A.F. Pikelner, O.B. Teryaev	
FLNP S.A. Kulikov	M.V. Bulavin, E.N. Kulagin, E.P. Shabalin	

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
		IAP NASB
	Gomel	GSTU
		GSU
Bulgaria	Sofia	SU
Canada	Vancouver	TRIUMF
	Montreal	UdeM
CERN	Geneva	CERN

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

02–2–1124–2015/2020	Priority: 1

Status: In-progress

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

Leader: V.V. Glagolev
Deputy: Yu.I. Davydov
Scientific leader: J.A. Budagov

Participating countries and international organizations:

Belarus, Bulgaria, Czech Republic, Georgia, Germany, United Kingdom, France, Italy, Russia, Slovakia, Switzerland, USA, Ukraine, Japan.

Issues addressed and main goals of research:

The muon anomalous magnetic moment a_μ 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, $\Delta a_\mu(Expt - SM) = (255 \pm 80) \times 10^{-11}$ (3.2σ), 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 and at MEG II experiment at PSI is a dedicated search for the CLFV processes $\mu^- N \to e^- N$, $\mu^+ \to e^+ \gamma$. Once neutrinos masses are included, the process is allowed but effectively still absent since the rate is proportional to $(\Delta m^2_{ij}/M^2_W)^2$, where Δm^2_{ij} 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 $\mu^- N \to e^- N$ and $\mu^+ \to e^+ \gamma$ 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.

Participation in the creation of and testing theoretical views in the topics. Study of CP-violation in the lepton sector with the help of neutrino. Study of hyperfine interactions of an acceptor impurity in semiconductors with the aid of negative muons. Investigation of the behavior of positive muons in systems with magnetic nanoparticles.

Expected major results in the current year:

- Simulation for e.m. calorimeter calibration of the Mu2e experiment.
- Tests of the CsI and BaF_2 e.m. calorimeter elements on the gamma sources and electron beam.
- Participation in the construction and tests of modules of scintillator counters for the veto system. Quality control.
- Support of the final version of visualization and control software.
- Participation in data taking runs and data analysis.
- Participation in the radiation hardness tests of the detector elements.
- Analysis of the experimental data on the radiative pion decay collected by the PEN experiment.
- Participation in development of the positron tracker for the MEG-II experiment, DAQ, data analysis.

- Participation in the data taking and analysis of experimental data using CERN hadron beams.
- Software development for data processing and analysis.
- Study of the behavior of magnetic nanoparticles with high magnetic anisotropy by the muon spin rotation technique.
- Methodical work with TRITON components.

List of projects:

Project	Leader	Priority (period of realization)
1. Search for new physics in experiments with high-intensity muon beams	V.V. Glagolev	1 (2015 – 2020)

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, A.V. Guskov, Yu.N. Kharzheev, V.I. Kolomoets, S.M. Kolomoets, Yu.A. Koultchitski, M.V. Lyablin, V.M. Romanov, A.V. Sazonova, A.N. Shalyugin, A.V. Simonenko, S.N. Studenov, I.A. Suslov, 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.S. Galoyan	
2. **Experiment Muon g-2**	**N.V. Khomutov**	R&D Realization
DLNP	V.A. Baranov, V.N. Duginov, N.A. Kuchinsky, N.P. Kravchuk, A.I. Rudenko, V.P. Volnykh	
VBLHE	S.A. Movchan	
LRB	V.A. Krylov	
3. **Experiment MEG II**	**N.V. Khomutov**	R&D Realization
DLNP	V.A. Baranov, V.V. Glagolev, Yu.I. Davydov, N.A. Kuchinsky, N.P. Kravchuk, A.V. Krasnoperov, V.L. Malyshev, A.M. Rozhdestvensky, A.V. Simonenko, I.V. Titkova	
VBLHEP	A.O. Kolesnikov	
LRB	V.A. Krylov	

4. **Experiment PEN**	**N.A. Kuchinsky**	Data processing
DLNP	V.A. Baranov, N.V. Khomutov, S.M. Korenchenko, A.S. Khrykin, E.S. Kuzmin, A.M. Rozhdestvensky, E.P. Velicheva, V.P. Volnykh	
BLTP	Yu.M. Bystritsky	
5. **CERN Neutrino platform**	**B.A. Popov**	Data taking Data processing
DLNP	N. Atanov, A. V. Krasnoperov, V.V. Lyubushkin, S.V. Tereschenko, V.V. Tereschenko	
6. **Experiment MUSPIN**	**V.N. Duginov**	Data taking Data analysis
DLNP	E.I. Bunyatova, K.I. Gritsay, A.I. Rudenko, G.D. Soboleva	
FLNP	M. Balasoiu + 2 pers.	
7. **Experiment TRITON**	**D.L. Demin**	Data analysis
DLNP	N.A. Baranova, A.I. Boguslavsky, V.N. Duginov, E.D. Gorodnichev, K.I. Gritsay, S.A. Gustov, V.I. Kolomoets, E.V. Kolesov, A.D. Konin, A.P. Kustov, A.I. Rudenko, Yu.A. Polyakov, N.A. Shakun, V.I. Smirnov, Z.U. Usubov	
FLNR	S.A. Yukhimchuk	
LRB	V.B. Buchnev, V.Yu. Schegolev	

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	NRC KI PNPI
Romania	Bucharest	IFIN-HH
Slovakia	Bratislava	IP SAS
		CU
Switzerland	Villigen	PSI
Ukraine	Kharkov	ISMA NASU
USA	Batavia, IL	Fermilab
	Charlottesville, VA	UVa
	Lexington, KY	UK

02–2–1099–2010/2023	Priority: 1

Status: Extended

Study of Neutrino Oscillations

Leaders: D.V. Naumov
A.G. Olshevskiy

Participating countries and international organizations:

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

Issues addressed and main goals of research:

- Measurement of the θ_{13} neutrino mixing angle and Δm^2_{ee} 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 major results in the current year:

- Physics analysis of the Daya Bay experiment data.
- Development of the methods of the mass hierarchy measurements and determination of neutrino oscillation parameters in NOvA and JUNO experiments.
- Data analysis in NOvA experiment.
- Study of systematic uncertainties related to the neutrino-nucleon cross sections for NOvA analysis.
- Use of NOvA experiment Remote Operation Centre at JINR for shifts.
- Preparation for the mass production of High Voltage for JUNO PMT.
- Mass test of JUNO PMT.
- Preparation of the OPERA TT detectors for the use in JUNO experiment.
- Measurement of JUNO veto system detector planes.
- Event reconstruction in Borexino detector.
- Analysis of SNO solar neutrino parameters in Borexino detector.

List of projects:

	Project	Leader	Priority (period of realization)
1.	BOREXINO	O.Yu. Smirnov	1 (1996 – 2019)
2.	Daya Bay/JUNO	D.V. Naumov	1 (2009 – 2020)
3.	NOvA	A.G. Olshevskiy	1 (2015 – 2020)

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **Experiment BOREXINO**	**O.Yu. Smirnov**	Data taking
DLNP	K.A. Fomenko, D.V. Korablev, A.P. Sotnikov, A.V. Vishneva	
VBLHEP	O.A. Zaimidoroga	
2. **Daya Bay/JUNO Project**	**D.V. Naumov** **M.O. Gonchar**	Data taking R&D
DLNP	N.V. Anfimov, T.A. Antoshkina, S.V. Biktemerova, I.V. Butorov, A.V. Chukanov, S.G. Dmitrievsky, K.A. Fomenko, D.V. Fedoseev, Yu.A. Gornushkin, O.E. Gorchakov, V.O. Gromov, N.M. Kolganov, A.V. Krasnoperov, N.A. Morozov, E.A. Naumova, I.B. Nemchenok, A.G. Olshevskiy, A.V. Rybnikov, A.B. Sadovsky, A.S. Selunin, O.Yu. Smirnov, S.A. Sokolov, A.P. Sotnikov, M.A. Strizh, K.A. Treskov	
3. **NOvA Project**	**A.G. Olshevskiy** **O.B. Samoylov**	Data taking
DLNP	V.A. Allakgverdian, V.V. Amvrosov, A.I. Antoshkin, N.V. Anfimov, A.E. Bolshakova, O.A. Klimov, Ch. Kullenberg, L.D. Kolupaeva, A.D. Morozova O.N Petrova, A.S. Sheshukov, A.P. Sotnikov	
BLTP	S.M. Bilenky, K.S. Kuzmin, V.A. Matveev, V.A. Naumov	
LIT	N.A. Balashov, A.V. Baranov, A.G. Dolbilov, E.A. Kuznetsov	
VBLHEP	I.D. Kakorin	
4. **Experiment OPERA**	**Yu.A. Gornushkin**	Data analysis
DLNP	A.V. Chukanov, S.G. Dmitrievsky, A.G. Olshevskiy, A.B. Sadovsky, A.P. Sotnikov, S.G. Vasina	
5. **Experiment DarkSide**	**O.Yu. Smirnov**	Data analysis
DLNP	K.A. Fomenko, O.E. Gorchakov, D.V. Korablev, O.B. Samoylov, A.P. Sotnikov, A.S. Sheshukov, A.V. Vishneva	
6. **Development of new photodetectors and the equipment for application in registering systems of neutrino experiments**	**N.V. Anfimov**	R&D
DLNP	A.I. Antoshkin, V.V. Chalyshev, I.E. Chirikov-Zorin, D.V. Fedoseev, K.I. Kuznetsova A.G. Olshevskiy, A.V. Rybnikov, A.V. Selunin, A.P. Sotnikov, S.A. Sokoklv	
VBLHEP	Z.Ya. Sadygov	

Collaboration

Country or International Organization	City	Institute or Laboratory
Germany	Hamburg	Univ.
	Aachen	RWTH
Czech Republic	Prague	CU
France	Strasbourg	CRN
Italy	Salerno	INFN
	Milan	UNIMI
China	Beijing	IHEP CAS
Romania	Bucharest	IFIN-HH
Slovakia	Bratislava	CU
USA	Indianapolis, IN	IUPUI
	Batavia, IL	Fermilab
	Cambridge, MA	Harvard Univ.
Turkey	Ankara	METU
Japan	Tokyo	Toho Univ.

02–0–1108–2011/2019	Priority: 1

Status: Being concluded

Experiment PANDA at FAIR

Leader: G.D. Alexeev
Deputy: A.N. Skachkova

Participating countries and international organizations:

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

Issues addressed and main goals of research:

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

Expected major results in the current year:

- Inclusion of MC generators into the PANDA software and optimization of the event analysis.
- 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, G.A. Golovanov, S.A. Kutuzov, A.A. Piskun, 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	V.A. Arefev, V.I. Astakhov, M.Yu. Barabanov, V.K. Dodokhov, A.A. Efremov, A.A. Feshchenko, A.S. Galoyan, V.I. Lobanov, Yu.Yu. Lobanov, P.V. Nomokonov, I.A. Olex, E.A. Strokovsky, S.S. Shimansky	
LIT	Gh. Adam, V.V. Uzhinsky	
BLTP	A.V. Efremov, A.S. Sorin, O.V. Teryaev	

Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	INP BSU
CERN	Geneva	CERN
Czech Republic	Prague	CU
Germany	Darmstadt	GSI
Russia	Protvino	IHEP
	Omsk	OB IM SB RAS
	St. Petersburg	Neva-Magnet
Slovakia	Bratislava	IP SAS

02–2–1125–2015/2020	Priority: 1

Status: In-progress

Astrophysical Studies in the Experiment TAIGA

Leader: L.G. Tkachev
Deputies: V.M. Grebenyuk
A.V. Borodin

Participating countries and international organizations:

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

Issues addressed and main goals of research:

- 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 (thr 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 with TUS.
- 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≈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 major results in the current year:

- Design and production of second IACT for TAIGA experiment.
- Participation in the MC simulation of TAIGA experiment and data analysis.
- Participation in the data taking of the TUS experiment and data analysis.
- Participation in the data taking of the NUCLEON experiment and data analysis.
- Design and fabrication ОЛИВЭ–HERO prototype and beam tests of it at the SPS CERN.

List of projects:

	Project	Leader	Priority (period of realization)
1.	TAIGA	L.G. Tkachev	1 (2015 – 2020)

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **Experiment TAIGA**	**L.G. Tkachev**	Realization
DLNP	A.N. Borodin, A.N. Demenko, M. Finger, V.M. Grebenyuk, F.F. Grinyuk, A.I. Kalinin, M.V. Lavrova, U. Nurtaeva, A. Pan, V.M. Romanov, S.Yu. Porokhovoy, M. Slunečhka, V. Slunečhkova, B.M. Sabirov, Y.I. Sagan	
VBLHEP	N.V. Gorbunov	
LIT	V.N. Shigaev	
2. **Experiment TUS**	**L.G. Tkachev**	Realization
DLNP	V.M. Grebenyuk, F.F. Grinyuk, A.I. Kalinin, M.V. Lavrova, U. Nurtaeva, S.Yu. Porokhovoy, A.V. Tkachenko, M. Slunečhka, V. Slunečhkova	
VBLHEP	N.V. Gorbunov	
3. **Experiment NUCLEON**	**L.G. Tkachev**	Realization
DLNP	A.N. Borodin, V.M. Grebenyuk, M.V. Lavrova, U. Nurtaeva, N.I. Kalinin, B.M. Sabirov, A.B. Sadovsky, S.Yu. Porokhovoy, A.V. Tkachenko	
VBLHEP	N.V. Gorbunov	
LIT	V.N. Shigaev, S.K. Slepnev	
FLNP	A.D. Rogov	

Collaboration

Country or International Organization	City	Institute or Laboratory
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
	Moscow, Troitsk	INR RAS

02–2–1134–2018/2019	Priority: 1

Status: Being concluded

Experiment COMET at J-PARC

Leader: Z. Tsamalaidze

Participating countries and international organizations:

Belarus, Czech Republic, Georgia, Germany, France, Kazakhstan, Russia, United Kingdom, Japan.

Issues addressed and main goals of research:

The goal of the COMET experiment at the accelerator of J-PARC is the search for a neutrinoless conversion of a muon into an electron $\mu^- N \to e^- N$, in which the lepton number in the charged sector does not conserve. Within the SM, modified taking into account the neutrino oscillations, the expected rate is less than 10^{-50} and so any observation of conversion would be a clear signal of a new physics beyond the SM. A measurement at the level 10^{-17} for conversion, which is the COMET goal, is a factor of 10000 better than that of the current experimental limit $B(\mu^- + Au \to \mu e^- + Au) < 7 \cdot 10^{-13}$ from SINDRUM-II at PSI.

Expected major results in the current year:

- 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.
- Calibration of LYSO crystals.

List of projects:

Project	Leader	Priority (period of realization)
1. COMET	Z. Tsamalaidze	1 (2017 – 2019)

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. Project COMET	**Z. Tsamalaidze**	R&D Realization
DLNP	V.N. Duginov, P.G. Evtukhovich, I.L. Evtukhovich, K.I. Gritsai, Kh. Khubashvili, E.S. Kaneva, A.S. Moiseenko, B.M. Sabirov, A.G. Samartsev, N. Tsverava, E.P. Velicheva, A.D. Volkov	
LIT	G. Adamov, A. Khvedelidze	
BLTP	G.A. Kozlov	
VBLHEP	V.V. Elsha, T.L. Enik, S.A. Movchan, S.N. Shkarovsky	

Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	IP NASB
		BSU
		INP BSU
Czech Republic	Prague	CU
		CTU
France	Paris	IN2P3
Georgia	Tbilisi	HEPI-TSU
		GTU
		UG
Germany	Dresden	TU Dresden
Japan	Osaka	Osaka Univ.
	Tsukuba	KEK
	Fukuoka	Kyushu Univ.
Kazakhstan	Almaty	INP
Russia	Moscow	ITEP
		NNRU "MEPhI"
	Novosibirsk	BINP SB RAS
		NSU
United Kingdom	London	Imperial College

02–1–1106–2011/2019	Priority: 1

Status: Being concluded

Investigations of Compressed Baryonic Matter at the GSI Accelerator Complex

Leaders: V.P. Ladygin
V.V. Ivanov

Deputy: O.Yu. Derenovskaya

Participating countries and international organizations:

Czech Republic, Germany, Romania, Russia, Slovakia, Ukraine.

Issues addressed and main goals of research:

Expertize of the design of the superconducting dipole magnet, design and development of straw detector prototype 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 major results in the current year:

- Expertize and preparation of the drawings of individual parts of the superconducting dipole magnet for the CBM experiment.
- Design and testing of the straw detector prototype.
- Development of the algorithms and software for the trigger and data analysis.
- Simulation of the multiparticle dynamics in heavy ion collisions.
- Development of the mathenatical 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. Participation in experimental data analysis. 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 O.V. Fateev	2 (2010 – 2021)

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **CBM Project** **Expertize of the design and manufacture of the superconducting dipole magnet and straw detector prototype. Development of the algorithms and software for trigger, simulation and data analysis**	**V.P. Ladygin** **V.V. Ivanov**	Realization
VBLHEP	S.P. Avdeev, I.V. Boguslavsky, A.V. Bychkov, D.V. Dementiev, V.V. Elsha, O.V. Fateev, Yu.V. Gusakov, A.P. Ierusalimov, G.D. Kekelidze, N.B. Ladygina, V.M. Lysan, A.I. Malakhov, Yu.A. Murin, A.D. Sheremetiev, A.L. Voronin, A.P. Zinchenko, N.I. Zamyatin	
LIT	P.G. Akishin, E.P. Akishina, E.I. Alexandrov, I.N. Alexandrov, D.V. Belyakov, O.Yu. Derenovskaya, I.A. Filozova, V.V. Ivanov, V.V. Ivanov (jr), P.I. Kisel, G.E. Kozlov, A.V. Kryanev, S.A. Lebedev, A.M. Raportirenko, T.P. Sapozhnikova, P.V. Zrelov	
BLTP	D. Blaschke, S.G. Bondarenko, V.V. Burov, E.-M. Ilgenfritz, V.D. Toneev	
2. **Experiment HADES**	**V.P. Ladygin**	Data taking Data analysis
VBLHEP	A.V. Belyaev, O.V. Fateev, A.P. Ierusalimov, S.G. Reznikov, 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
Czech Republic	Řež	NPI CAS
Germany	Darmstadt	GSI
	Dresden	HZDR
	Frankfurt/Main	Univ.
	Giessen	JLU
	Heidelberg	Univ.
Romania	Bucharest	IFIN-HH
Russia	Moscow	ITEP
		SINP MSU

		NNRU "MEPhI"
	Moscow, Troitsk	INR RAS
	Protvino	IHEP
Slovakia	Bratislava	IP SAS
		CU
Ukraine	Kiev	BITP NASU

02–1–1096–2010/2019	Priority: 1

Status: Being concluded

Study of Rare Charged Kaon Decays and Search for Dark Sector in Experiments at the CERN SPS

Leaders: V.D. Kekelidze
Yu.K. Potrebenikov

Deputy: D.V. Peshekhonov

Participating countries and international organizations:

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

Issues addressed and main goals of research:

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.

The Na64 experiment is a fixed–target esperiment at the CERN SPS combining the active beam dump and missing energy techniques to search for rare events. The experiment will build and operate a fully germetic detector with the primary goal to search for light dark bozons (Z') from dark sector that are coupled to photons, e.g. dark photons (A'), or sub–GeV Z' coupled only to quarks. In some cases the Z' is coupled only to μ or τ, so we call the Z' the dark leptonic gauge boson. The experiment is also capable to search K_L invisible decay, which is complementary to $K + \pi^+ + \nu\nu$, and invisible decays of $\pi^0, \eta, \eta^{'}$, K_S mesons.

Expected major results in the current year:

- 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 a nd support of the NA62 straw detectors will be carried out.
- Tracking detectors for NA64 experiment based on the straw tube technology will be developed and manufactured.
- Data taking by the NA64 set–up and data analysis will be carried out.

List of projects:

Project	Leader	Priority (period of realization)
1. NA62	V.D. Kekelidze Yu.K. Potrebenikov	1 (2010 – 2021)
2. NA64	V.A. Matveev D.V. Peshekhonov	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	A.A. Belkova, D. Baygarashev, V.P. Falaleev, T.L. Enik, D.D. Emelyanov, S.R. Gevorgyan, L.N. Glonti, V.N. Gorbunova, E.A. Gudzovsky, A.M. Korotkova, D.T. Madigozhin, M.H. Misheva, N.A. Molokanova, S.A. Movchan, I.A. Polenkevich, S.N. Shkarovsky	
2. **Experiment NA64**	**V.A. Matveev** **D.V. Peshekhonov**	Preparation Data taking Data analysis
VBLHEP	I.V. Boguslavsky, T.L. Enik, A.A. Festchenko, G.D. Kekelidze, V.A. Kramarenko, V.M. Lysan, S.S. Parzhitsky, V.V. Pavlov, L.N. Tarasova, E.V. Vasilieva, P.V. Volkov, I.A. Zhukov, A.V. Zinin	

Collaboration

Country or International Organization	City	Institute or Laboratory
Belgium	Louvain-la-Neuve	UCL
Bulgaria	Sofia	SU
	Blagoevgrad	SWU
	Plovdiv	PU
CERN	Geneva	CERN
Canada	Vancouver	UBC
		TRIUMF
Chile	Valparaiso	UTFSM
Czech Republic	Prague	CU
Germany	Mainz	JGU
	Bonn	UniBonn
Italy	Florence	INFN
	Ferrara	INFN
	Frascati	INFN LNF
	Naples	INFN
	Perugia	INFN
	Pisa	INFN
	Rome	INFN
		Univ. "Tor Vergata"
	Turin	INFN
Mexico	San Luis Potosi	UASLP
Romania	Bucharest	IFIN-HH

Russia	Moscow, Troitsk	INR RAS
	Moscow	LPI RAS
	Protvino	IHEP
	Tomsk	TPU
Slovakia	Bratislava	CU
Switzerland	Zurich	ETH
United Kingdom	Birmingham	Univ.
	Bristol	Univ.
	Glasgow	U of G
	Lancaster	LU
	Liverpool	Univ.
USA	Boston, MA	BU
	Fairfax, VA	GMU
	Menlo Park, CA	SLAC
	Merced, CA	UCMerced
	Upton, NY	BNL

02–0–1083–2009/2019	Priority: 1

Status: Being concluded

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.

Issues addressed and main goals of research:

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–nucleaus 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 major results in the current year:

- 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 – 2020)

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, V.D. Kalagin, A.Yu. Kamenev, L.G. Kobylets, A.M. Kurenkov, A.I. Malakhov, V.A. Smirnov, N.I. Zamyatin	
	DLNP	M. Finger, M. Finger (Jn.), M. Slunečhka, V. Slunečhkova, Z. Tsamalaidze	
	LIT	A. Khvedelidze	
	GA&C	B.S. Yuldashev	
2.	**Forward muon station ME1/1**	**V.Yu. Karjavin**	Commissioning Maintenance Data taking
	VBLHEP	S.E. Vasiliev, A.O. Golunov, I.A. Golutvin, N.V. Gorbunov, Yu.V. Ershov, N.N. Evdokimov, A.Yu. Kamenev, A.M. Kurenkov, A.M. Makan'kin, V.V. Perelygin, A.V. Zarubin	
	LIT	V.V. Palchik, N.N. Voytishin	
3.	**Upgrade of the CMS detectors**	**I.A. Golutvin**	Realization
	VBLHEP	V.Yu. Alexakhin, S.V. Afanasiev, P.D. Bunin, N.V. Gorbunov, S.E. Vasiliev, Yu.V. Ershov, V.Yu. Karjavin, A.M. Kurenkov, A.M. Makan'kin, A.I. Malakhov, V.V. Perelygin, V.A. Smirnov, A.V. Zarubin	
	LIT	V.V. Palchik, N.N. Voytishin	
	GA&C	B.S. Yuldashev	
4.	**Reserch physics programme with the CMS detector**	**S.V. Shmatov** **I.A. Golutvin**	Realization
	VBLHEP	V.Yu. Alexakhin, S.V. Afanasiev, M.G. Gavrilenko, I.N. Gorbunov, I.I. Belotelov, P.D. Bunin, A.Yu. Kamenev, L.G. Kobylets, A.V. Lanev, A.I. Malakhov, M.V. Savina, D. Seitova, V.V. Shalaev, S.G. Shulga, I.A. Zhizhin, V.A. Zykunov, A.V. Zarubin	
	LIT	V.V. Korenkov, D.A. Oleynik, G.A. Ososkov, V.V. Palchik, A.Sh. Petrosyan, N.N. Voytishin	
	BLTP	A.B. Arbuzov, S.G. Bondarenko, A.V. Efremov, A.V. Kotikov, G.A. Kozlov, A.V. Sidorov, O.V. Teryaev	
	DLNP	G.A. Golovanov, M. Finger, M. Finger (Jr.), N.B. Skachkov, A.N. Skachkova, A.Yu. Verkheev	
	GA&C	B.S. Yuldashev	
5.	**Development and investigation of the scintillator module prototype of the CMS Hadron Calorimeter**	**I.A. Golutvin** **A.I. Malakhov**	Realization
	VBLHEP	S.V. Afanasiev, Yu.V. Ershov, N.V. Gorbunov, A.M. Kurenkov, V.A. Smirnov, E.V. Sukhov, T.V. Trofimov, V.V. Ustinov N.I. Zamyatin	

6. **Development of software for distributed computation, data processing and analysis based on GRID–technology**	**V.V. Korenkov**	Realization

LIT	A.O. Golunov, I.A. Filozova, V.V. Mitsyn, V.V. Palchik, R.N. Semenov, 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	UAntwerp
	Brussels	ULB
		VUB
	Mons	UMONS
Brazil	Rio de Janeiro, RJ	CBPF
		UERJ
		UFRJ
	Sao Paulo, SP	Unesp
Bulgaria	Sofia	SU
		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
	Strasbourg	IPHC

Georgia	Tbilisi	HEPI-TSU
		AIP TSU
Germany	Berlin	HU
	Aachen	RWTH
	Karlsruhe	KIT
Greece	Athens	INP NCSR "Demokritos"
		UoA
	Ioannina	UI
Hungary	Budapest	Wigner RCP
	Debrecen	Atomki
		UD
India	Mumbai	BARC
		TIFR
	Bhubaneswar	IOP
	Chandigarh	PU
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
	Chongju	CBNU
Russia	Moscow	ITEP
		LPI RAS
		NNRU "MEPhI"
		SINP MSU

		NIKIET
	Moscow, Troitsk	INR RAS
	Gatchina	NRC KI PNPI
	Dolgoprudny	MIPT
	Novosibirsk	NSU
	Protvino	IHEP
	Snezhinsk	VNIITF
	St. Petersburg	Electron
	Tomsk	TPU
	Zhukovsky	MDB
Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	STU
Spain	Madrid	CIEMAT
		UAM
	Oviedo	UO
	Santander	IFCA
Switzerland	Zurich	ETH
		UZH
	Villigen	PSI
	Basel	Uni Basel
Taiwan	Taipei	NTU
	Chung–Li	NCU
Turkey	Adana	CU
	Ankara	METU
Ukraine	Kharkov	NSC KIPT
		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
	Pittsburgh, PA	CMU
	Piscataway, NJ	Rutgers
	Princeton, NJ	PU
	Riverside, CA	UCR
	Rochester, NY	UR
	Tallahassee, FL	FSU
	Tuscaloosa, AA	UA
Uzbekistan	Tashkent	INP AS RUz

02–0–1085–2009/2019	Priority: 1

Status: Being concluded

Studies of the Nucleon and Hadron Structure at CERN

Leader: A.P. Nagaytsev
Deputy: A.V. Guskov

Participating countries and international organizations:

CERN, Czech Republic, France, Germany, India, Israel, Italy, Japan, Poland, Portugal, Russia, Taiwan, USA.

Issues addressed and main goals of research:

Studies of the generalized parton distributions in various exclusive processes. Study of the mechanisms of exclusive production of photons, pions and vector mesons in the processes of deep inelastic scattering of muons on nuclei (DIS) and in processes of deep inelastic virtual Compton scattering (DVCS). Measurements of the polarizability of a pion. Study of the structure of nucleons in Drell–Yan processes. Study of inclusive and semi–inclusive processes in DIS reactions of muons and hadrons on polarized targets.

- Measurements of the structure functions of a nucleon, polarized parton distributions of nucleons.
- Measurements of the structure of nucleons in the Drell–Yan processes.
- Spin effects in hadron interactions at 0.3-3.0 GeV.
- Study of the mechanisms of exclusive production of photons, pions and ρ–mesons in DIS and DVCS processes.
- Measurement of the polarizability of the pion.
- Creation and development of a set of programs for modeling and data processing. System support for CERN software.
- Preparation of detectors for the COMPASS–II spectrometer.

Expected major results in the current year:

- Results on azimuthal asymmetries with a longitudinally polarized deuterium target.
- Preliminary results on the polarization of the pion from the 2012 data.
- Results on kaon multiplicities.
- Observation of the exclusive production of the X(3872) in the reactions muons with nuclear targets.
- Software development and modeling of vaious reactions studied on the COMPASS–II spectrometer. Analysis of data in JINR and preparation of publications.
- Theoretical studies on the program COMPASS–I and COMPASS–II.

List of projects:

	Project	Leader	Priority (period of realization)
1.	COMPASS–II	A.P. Nagaytsev	1 (2011 – 2020)

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	V.A. Anosov, G.V. Meshcheryakov, A.S. Yukaev	
DLNP	A.S. Selyunin	
2. **Electromagnetic calorimeter**	**A.P. Nagaytsev,** **N.V. Anfimov**	Maintenance
VBLHEP	V.A. Anosov, V.I. Astakhov, O.P. Gavrishchuk, G.V. Meshcheryakov, A.P. Nagaytsev	
DLNP	A.I. Antoshkin, V.O. Gromov, D.V. Fedossev, V.M. Kudryavtsev, M.V. Nikitin, A.G. Olshevskiy, T.V. Rezinko, A.V. Rybnikov, A.S. Selyunin, I.E. Tchirikov–Zorin	
3. **Muon system**	**G.D. Alekseev**	Maintenance
DLNP	V.M. Abazov, G.A. Golovanov, A.A. Piskun, A.G. Samartsev, V.V. Tokmenin, L.S. Vertogradov, N.I. Zhuravlev	
4. **Polarized target**	**Yu.F. Kiselev**	Maintenance
VBLHEP	Yu.F. Kiselev	
5. **System of the data taking**	**V.N. Frolov**	Maintenance
DLNP	V.N. Frolov	
6. **Software devlopment. Data analysis**	**E.V. Zemlyanichkina** **A.V. Guskov**	Realization
VBLHEP	R.R. Akhunzyanov, R. Gushcherski, A.V. Ivanov, Yu.I. Ivanshin, V.S. Batozskaya, O.M. Kuznetsov, G.V. Meshcheryakov, A.P. Nagaytsev, N.S. Rogacheva, D.V. Peshekhonov, I.A. Savin, G.I. Smirnov, E.A. Salmina	
DLNP	N.V. Anfimov, A.I. Antoshkin, A.F. Gridin, I.A. Denisenko, A.V. Maltsev, A.G. Olshevskiy, T.V. Rezinko, A.V. Rybnikov, A.A. Rymbekova, A.S. Selyunin	
LIT	P.V. Zrelov, A.Sh. Petrosyan	
7. **Measurements of generalized parton distributions**	**A.P. Nagaytsev** **A.V. Guskov** **I.A. Savin**	Realization
VBLHEP	R.R. Akhuzyanov, V.S. Batozskaya, R. Guscherski, G.V Meshcheryakov, O.M. Kuznetsov, N.S. Rogacheva, V.D. Peshekhonov, E.A. Salmina, G.I. Smirnov, O.V. Teryaev, E.V. Zemlyanichkina	

	DLNP	I.A. Denisenko, A.V. Maltsev, A.G. Olshevskiy, A.A. Rymbekova	
	BLTP	A.V. Efremov	
8.	**Studies of Drell–Yan processes**	**A.V. Guskov**	Realization
	DLNP	I.A. Denisenko, A.V. Guskov, A.O. Gridin, A.V. Maltsev, E.O. Mitrofanov, A.A. Rymbekova	
9.	**Spin effects in hadron interactions at 0.3-3.0 GeV**	**A.V. Kulikov** **D.A Tsirkov**	Data processing
	DLNP	T.I. Azaryan, S.N. Dymov, V.I. Komarov, V.S. Kurbatov, Zh. Kurmanaliev, A. Kunsafina, V.V. Shmakov, Yu.N. Uzikov, B.Zh. Zalikhanov	
10.	**Studies of semi-inclusive reactions**	**I.A. Savin** **E.V. Zemlyanichkina**	Realization
	VBLHEP	Yu.I. Ivanshin, N.O. Mitrofanov, N.S. Rogacheva, E.A. Salmina	
II.	**Theoretical studies**	**A.V. Efremov**	Realization
	BLTP	A.E. Dorokhov, S.B. Gerasimov, O.V. Teryaev, A.V. Kotikov, A.M. Sidorov	

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
CERN	Geneva	CERN
Czech Republic	Prague	CU
	Brno	BUT
	Liberec	TUL
France	Saclay	SPhN CEA DAPNIA
Germany	Bielefeld	Univ.
	Bochum	RUB
	Bonn	UniBonn
	Freiberg	TUBAF
	Hamburg	DESY
	Jülich	FZJ
	Munich	TUM
	Mainz	JGU
Israel	Tel Aviv	TAU
Italy	Turin	INFN
	Trieste	INFN
India	Kolkata	MIERE
Japan	Yamagata	Yamagata Univ.
Poland	Warsaw	WUT
	Otwock-Swierk	NCBJ

Portugal	Aveiro	UA
	Lisbon	LIP
Russia	Moscow	LPI RAS
	Tomsk	TPU
	Protvino	IHEP
Taiwan	Taipei	AS
USA	Urbana, IL	I

02–1–1086–2009/2020	Priority: 1

Status: In-progress

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

Leaders: E.A. Strokovsky
E.S. Kokoulina
D.O. Krivenkov

Participating countries and international organizations:

Belarus, Czech Republic, Japan, Russia, Ukraine.

Issues addressed and main goals of research:

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 extremally high multiplicity;
study of spectra and yields of soft photons in deuteron–nucleus and nucleus–nucleus interactions.

Expected results:

- Experimental conclusion about existence of the hypernucleus ${}^{6}_{\Lambda}H$.
- New experimental data on properties of the lightest hypernuclei and experimental verification of corresponding theoretical models for such hypernuclei.
- New experimental data about the drip–line location for loosely bound light hypernuclei with high neutron excess, necessary for development of the theory of the neutron–rich hypernuclei and models of their production in non-central nucleus–nucleus interactions.
- Comparison of the energy spectra (in the region of several MeV) of protons, emitted in interactions with nuclear targets of various (from deuterons to heavy nuclei) nuclear beams from the Nuclotron and measured at different multiplicity of charged and neutral particles as well as at different emission angles of such photons, with theoretical predictions. Verification of various physical hypotheses about emission of the "direct" photons in nuclei–nuclei interactions.
- Experimental estimation (or determination of upper limit) of cross sections for production of new hypothetical resonances, decaying via 2γ mode. Determination of conditions for pion condensate formation at the high multiplicity region by momentum spectra.

Expected major results in the current year:

- Upgrade of the tracking system of the HyperNIS magnetic spectrometer by installing additional planes of GEM detectors.
- Analysis of data from LEPS spectormeter on vector–meson photoproduction by polarized photons.
- Monte-Carlo simulation of performance of the 2–arm electromagnetic calorimeter ("shashlyk"–type, 9 modules and the BGO–crystal based 2–nd calorimeter), to be installed at the SVD–2 setup. Production of the necessary FE–electronics with low gamma–detection threshold ($\sim$ 5-8 MeV) for this calorimeter.
- Production of the pre–shower and a movable support for the EM–calorimeter (with 9 modules) for their integration into the SVD–2 setup. Calibration of the EM modules at low energy beams of electron accelerators (DLNP of JINR, INR RAS (Troitsk)).

- Preparation of the experiment 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 SVD–2 setup.

List of projects:

Project	Leader	Priority (period of realization)
1. HyperNIS	E.A. Strokovsky	1 (2010 – 2021)

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **Experiment NIS–GIBS**	**E.A. Strokovsky** **J. Lukstins** **D.O. Krivenkov**	Realization Data taking
VBLHEP	V.D. Aksinenko, A.V. Averyanov, A.N. Bayeva, S.N. Bazylev, A.E. Baskakov, Yu.T. Borzunov, D.V. Dementiev, V.B. Dunin, A.A. Feschenko, A.A. Fedyunin, S.V. Gertsenberger, A.M. Korotkova, A.V. Konstantinov, V.T. Matyushin, A.I. Maksimchuk, Yu.A. Murin, O.V. Okhrimenko, S.N. Plyashkevich, N.G. Parfenova, P.A. Rukoyatkin, A.V. Shipunov, M.O. Shitenkov, R.A. Salmin, A.D. Sheremetiev, A.V. Shutov, N.A. Shutova, V.M. Slepnev, A.L. Voronin	
DLNP	N.V. Atanov, B.A. Popov, V.V. Tereschenko, S.V. Tereschenko	
OCE	A.N. Parfenov	
2. **Experiment NEMAN**	**E.S. Kokoulina** **V.A. Nikitin**	Project preparation Data taking
VBLHEP	V.P. Balandin, Yu.T. Borzunov, V.B. Dunin, O.P. Gavrischuk, A.S. Gribovsky, N.A. Kuzmin, V.I. Kireev, A.V. Konstantinov, D.A. Kirillov, V.A. Nikitin, V.A. Pavlyukevich, Yu.P. Petukhov, I.A. Rufanov, M.V. Tokarev, R.A. Shindin, A.I. Yukaev, N.K. Zhidkov, V.A. Zykunov	
BLTP	Yu.A. Bystritsky	

Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	IAP NASB
	Gomel	GSTU

		"Radatech"
		GSU
Czech Republic	Prague	CTU
Japan	Osaka	RCNP
Russia	Moscow	SINP MSU
		NNRU "MEPhI"
		"Azimuth-Photonics"
	Protvino	IHEP
	St. Petersburg	SPbSPU
	Syktyvkar	DM Komi SC UrB RAS
Slovakia	Banska Bistrica	UMB
Ukraine	Kiev	BITP NASU

02–0–1065–2007/2019	Priority: 1

Status: Being concluded

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: V.D. Kekelidze
A.S. Sorin

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

Participating countries and international organizations:

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

Issues addressed and main goals of research:

Search and investigation of phase transitions in strongly interacting nuclear matter at extremely high baryon densities, study of the nucleon spin structure, of light nuclei and polarization phenomena in few nucleon systems. Development of theoretical models of the studied 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. Investigation of reaction dynamics and studing modifications of hadron properties in nuclear matter, near-threshold strange hyperons production and search for hyper nuclei in interactions of the Nuclotron extracted ion beams with fixed targets at the BM@N detector. Investigation of the nuclear structure at short internucleon distances at the BM@N detector. Development and stage-by-stage creation of the NICA heavy ion collider accelerator complex, the multi-purpose detector (MPD/NICA) and spin physics detector (SPD/NICA) for experiments with colliding heavy ions beams. Modernization of extraction beam lines. Carrying out of experiments with ion beams and polarized deuteron beams at the Nuclotron.

Expected major results in the current year:

- Development and extension of the physics programme of the NICA "White Paper" – project. Generation of new theoretical results for processes of strong interactions in the non-perturbative QCD region, development and tests of description models for nuclear matter properties at sxtremely high temperatures and densities, investigation of possible nuclear matter states and buclear collision dynamics at extreme baryonic densities as well as observation of these phenomena in P–odd effects and spin asymmetries.
- Completion of the planned tasks within the Nuclotron–NICA project: Start the creation of the standard KRION-N heavy ion source. Development of beam diagnostics systems. Increasing the intensity of the beam from the SPI polarized particle source at the test bench. Investigations with Nuclotron beams for solving first–priority tasks on the accelerator development and of the NICA physics program implementation within running in available time. Designing the SC resonator prototype for the proton linear accelerator. Start of the designing proton and deuteron linear accelerator LILAC.
- Commissioning the HILAC linear accelerator ($z/A \geq 0.14$), achieving its design parameters. Development and put into operation of new test beds, upgrade of the engineering infrastructure. Assembling and testing the equipment for the beam injector channel from HILAC to the Booster. Testing the magnet cryostat system of the Booster.
- Production, assembling and testing the elements of systems of beam extraction and transporting from the Booster to the Nuclotron in working operation conditions.

- Updating the general layout of the NICA complex infrastructure. Approvement of the detailed design for the arrangement of NICA elements and systems. Continuation of construcrion works.
- Analysis of the BM@N experimental data on interaction of ion beams with fixed targets. Preparation of a technical design project for measurements with additional detectors and improved radiation protection. Analysis of the data from the SRC experiment. Realization of the decisions approved by the BM@N Collaboration board.
- Implementation of the stages of the technical design project of the MPD solenoid. Completion of works within the technical projects of the MPD subsystems. Start of mass–production of detectors.
- Presentation of the SPD project to the PAC for Particle Physics. Continuation of theoretical studies of the Matveev–Muradyan–Tavkhelidze–Drell–Yan processes, J/Ψ production processes and other processes in polarized proton and deuteron collisions.
- Implementation of start elements of the NICA/MPD/BM@N/SPD computer infrastructure in accodance with the work plan.

List of projects:

	Project	**Leader**	**Priority (period of realization)**
1.	Nuclotron–NICA	A.V. Butenko H.G. Khodzhibagiyan Scientific leader: I.N. Meshkov	1 (2011 – 2020)
2.	BM@N	M.N. Kapishin	1 (2012 – 2021)
	Subprojict SRC Probing Short-Range-Correlations	M.N. Kapishin E. Piasetzky Deputies: O. Hen T. Aumann	1 (2018 – 2021)
3.	MPD	V.M. Golovatyuk V.D. Kekelidze A.S. Sorin	1 (2011 – 2020)

List of activities:

	Activity or experiment **Laboratory or other Division of JINR** **Responsible person**	**Leaders** **Main researchers**	**Status**
1.1.	**NICA injection complex: technical design preparation and construction of the NICA injection complex: (sources of heavy ions and polarized light nuclei, HILAC linear accelerators of heavy ions and light nuclei of beam transportinh to the Nuclotron)**	**A.V. Butenko** **A.I. Govorov** **V.V. Kobets** **A.D. Kovalenko** **V.A. Monchinsky**	Realization
1.1.a.	**Commissioning the heavy ion source (KRION–6T)**	**E.D. Donets** **E.E. Donets**	Realization
1.1.b.	**Upgrade the polarized proton and deuteron source (SPI)**	**V.V.Fimushkin**	Realization

1.1.c.	**Development and construction of the beam injection systems and beam transportation channels. Development of the beam control and diagnostics systems**	**A.V. Tuzikov** **V.I. Volkov**	Realization
1.1.d.	**Design and start of the manufacturing of the new proton and light ion injector LILAC**	**A.V. Butenko** **A.I. Govorov** **K.A. Levterov** **B.V. Golovensky** **E.M. Syresin**	Projecting Realization
	VBLHEP	M.Yu. Averyanov, V.S. Alexandrov, A.V. Alfeev, V.P. Akimov, V.A. Andreev, A.M. Bazanov, A.V. Butenko, E.E. Donets, E.D. Donets, D.E. Donets, A.A. Fateev, V.V. Fimushkin, N.I. Garanzha, A.I. Govorov, B.V. Golovensky, E.V. Gorbachev, A.D. Kovalenko, V.V. Kobets, V.N. Karpinsky, V.V. Kovalev, O.S. Kozlov, S.Yu. Kolesnikov, V.V. Kosukhin, A.G. Kocherov, A.E. Kirichenko, L.V. Kutuzov, N.I. Lebedev, K.A. Levterov, D.A. Lyuosev, A.A. Martynov, S.V. Mikhaylov, V.A. Monchinsky, V.V. Myalkovsky, A.V. Nestrov, R.V. Pivin, D.O. Ponkin, Yu.V. Prokof'ichev, A.Yu. Ramzdorf, D.N. Rassadov, A.S. Romanov, S.V. Romanov, G.S. Sedykh, S.N. Sedykh, V.V. Seleznev, A.I. Sidorov, A.O. Sidorin, A.V. Smirnov, E.M. Syresin, V.S. Shvetsov, K.V. Shevtchenko, I.V. Shirikov, V.B. Shutov, V.V. Tarasov, N.D. Topilin, A.V. Tuzikov, Yu.A. Tumanova, V.P. Vadeev, V.I. Volkov, A.A. Voronin	
	GA&C	G.V. Trubnikov	
1.2.	**Assembling and start–up of the NICA Booster and its technological systems**	**A.V. Butenko** **H.G. Khodzhibagiyan** **I.N. Meshkov** **E.M. Syresin** **A.O. Sidorin**	Projecting Realization
1.2.a.	**Magnet cryostat system, vacuum system, system of electron cooling**	**A.R. Galimov** **A.V. Smirnov**	Realization
1.2.b.	**Power supply and energy evacuation system**	**E.V. Ivanov** **V.N. Karpinsky**	Projecting Realization
1.2.c.	**RF accelerating system of the Booster**	**O.I Brovko**	Realization
1.2.d.	**Diagnostics, injection, beam extraction and transportation systems**	**A.V. Tuzikov** **V.I. Volkov**	Projecting Realization
	VBLHEP	N.N. Agapov, A.S. Averichev, M.Yu. Averiyanov, V.A. Andreev, R.V. Andryukhin, A.V. Alfeev, A.M. Bazanov, V.V. Batin, Yu.T. Borzunov, A.V. Butenko, V.P. Chernyaev, D.E. Donets, V.M. Drobin, A.A. Fateev, A.R. Galimov, E.V. Gorbachev, A.Yu. Grebentsov, E.V. Ivanov,	

	VBLHEP	V.A. Isadov, V.N. Karpinsky, I.I. Kalagin, A.E. Kirichenko, H.G. Khodzhibagiyan, O.S. Kozlov, V.V. Kovalev, S.Yu. Kolesnikov, N.G. Kondratiev, A.V. Konstantinov, A.V. Kopchenov, S.A. Kostromin, A.G. Kochurov, A.V. Kudashkin, G.L. Kuznetsov, E.A. Kulikov, O.A. Kunchenko, N.I. Lebedev, S.V. Mikhaylov, V.A. Mikhaylov, V.V. Myalkovsky, A.V. Nesterov, A.L. Osipenkov, R.V. Pivin, N.V. Pilyar, O.V. Prozorov, S.V. Romanov, P.A. Rukoyatkin, T.V. Rukoyatkina, N.V. Semin, G.S. Sedykh, V.V. Seleznev, A.S. Sergeev, A.O. Sidorin, A.V. Smirnov, A.V. Shabunov, A.A. Shurygin, E.M. Syresin, V.V. Tarasov, N.D. Topilin, A.V. Tuzikov, Yu.A. Tumanova, B.V. Vasilishin, V.I. Volkov, L.V. Zinoviev	
	DLNP	E.V. Akhmanova, V.I. Hilinov, A.G. Kobets, I.N. Meshkov, O.S. Orlov, A.Yu. Rudakov, N.A. Rybakov, L.V. Soboleva, T.A. Stepanova, A.A. Sidorin, S.L. Yakovenko	
	GA&C	G.V. Trubnikov	
1.3.	**Development of the Nuclotron**	**A.V. Butenko** **A.O. Sidorin** **E.M. Syresin**	Projecting Realization
1.3.a,	**Magnet cryostst system, vacuum system**	**H.G. Khodzhibagiyan** **A.V. Smirnov**	Projecting Realization
1.3.b.	**Power supply and energy evacuation system**	**E.V. Ivanov** **V.N. Karpinsky**	Projecting Realization
1.3.c.	**RF accelerating system of the Nuclotron**	**O.I. Brovko**	Projecting Realization
1.3.d.	**Diagnostics, injection, beam extraction and transportation systems**	**E.V. Gorbachev** **P.A.Rukoyatkin** **V.I.Volkov**	Projecting Realization
	VBLHEP	A.S. Averichev, M.Yu. Averiyanov, V.A. Andreev, R.V. Andryukhin, A.V. Alfeev, A.M. Bazanov, V.V. Batin, V.V. Borisov, O.I. Brovko, A.V. Butenko, V.P. Chernyaev, D.E. Donets, E.V. Gorbachev, A.Yu. Grebentsov, E.V. Ivanov, V.A. Isadov, V.N. Karpinsky, A.E. Kirichenko, H.G. Khodzhibagiyan, O.S. Kozlov, V.V. Kovalev, S.Yu. Kolesnikov, N.G. Kondratiev, A.V. Konstantinov, A.V. Kopchenov, S.A. Kostromin, A.G. Kochurov, A.V. Kudashkin, G.L. Kuznetsov, E.A. Kulikov, O.A. Kunchenko, N.I. Lebedev, S.V. Mikhaylov, V.A. Mikhaylov, A.V. Merkuriev, V.V. Myalkovsky, A.V. Nesterov, A.L. Osipenkov, R.V. Pivin, O.V. Prozorov, S.V. Romanov, P.A. Rukoyatkin, N.V. Semin, G.S. Sedykh, V.V. Seleznev, A.S. Sergeev, A.O. Sidorin, A.V. Smirnov, A.A. Shurygin, E.M. Syresin, V.V. Tarasov, A.V. Tuzikov, V.B Vasilishin, V.I. Volkov	
	GA&C	G.V. Trubnikov	

1.4.	**Technical design, R&D of technological systems and construction of the NICA heavy ion collider with an energy of E_{CM}= 4–11 GeV and an average luminosity of $1 \cdot 10^{27}$ см$^{-2}$с$^{-1}$ and light polarized nuclie with a luminosity of $1 \cdot 10^{32}$ см$^{-2}$с$^{-1}$ (by protons, at E_{CM}=27 GeV)**	**A.D. Kovalenko** **S.A. Kostromin** **I.N. Meshkov** **E.M. Syresin**	Projecting Realization
1.4.a.	**Magnet cryostat and vacuum systems**	**A.R. Galimov** **H.G. Khodzhibagiyan** **A.V. Smirnov**	Realization
1.4.b.	**Power supply and energy evacuation system**	**E.V. Ivanov** **V.N. Karpinsky**	Realization
1.4.c.	**RF system of the Collider**	**O.I. Brovko** **A.Yu. Grebentsov**	Projecting Realization
1.4.d.	**Beam diagnostics, injection and transportation systems**	**A.V. Tuzikov** **V.I. Volkov**	Projecting Realization
1.4.e.	**Beam cooling systems**	**A.V. Smirnov** **A.O. Sidorin**	Projecting Realization
1.4.f.	**Systems of proton and deuteron polarization monitoring and control**	**A.D.Kovalenko**	Realization
	VBLHEP	A.S. Averichev, N.N. Agapov, V.S. Alexandrov, A.V. Alfeev, V.A. Andreev, R.V. Andryukhin, A.M. Bazanov, V.I. Batin, Ty.T. Borzunov, O.I. Brovko, A.V. Butenko, V.M. Drobin, A.V. Eliseev, A.A. Fateev, A.V. Filippov, A.R. Galimov, V.F. Get'man, E.V. Gorbachev, A.Yu. Grebentsov, Yu.V. Gusakov, E.V. Ivanov, V.N. Karpinsky, H.G. Khodzhibagiyan, A.E. Kirichenko, O.S. Kozlov, N.G. Kondratiev, A.V. Konstantinov, A.V. Kopchenov, S.A. Kostromin, G.L. Kuznetsov, E.A. Kulikov, N.I. Lebedev, A.A. Makarov, I.N. Meshkov, A.V. Nesterov, A.L. Osipenkov, R.V. Pivin, S.V. Romanov, P.A. Rukoyatkin, T.V. Rukoyatkina, N.V. Semin, A.O. Sidorin, A.V. Smirnov, E.M. Syresin, A.N. Scherbakov, V.V. Tarasov, N.D. Topilin, Yu.A. Tumanova, A.V. Tuzikov, V.I. Volkov	
	DLNP	E.V. Akhmanova, A.G. Kobets, V.I. Khilinov, I.N. Meshkov, O.S. Orlov, A.Yu. Rydakov, N.A. Rybakov, L.V. Soboleva, T.A. Stepanova, A.A. Sidorin, E.M. Syresin, B.V. Vasilishin, V.I. Volkov, S.L. Yakovenko	
	LRB	V.N. Buchnev, G.N. Timoshenko, V.Yu. Schegolev	
	GA&C	G.V. Trubnikov	
1.5.	**R&D, creation and development of cryogenic systems**	**N.N. Agapov** **H.G. Khodzhibagiyan**	Projecting Realization

	VBLHEP	A.B. Arefiev, V.I. Batin, N.A. Baldin, M.A. Basheva, D.M. Belov, Yu.T. Borzunov, V.M. Drobin, N.L. Egorova, N.E. Emelyanov, E.Yu. Filippova, I.N. Goncharov, S.P. Gorelikov, E.V. Gromova, S.V. Gudkov, E.Yu. Ivanenko, E.V. Ivanov, M.V. Kondratiev, K.K. Kozlovski, A.V. Konstantinov, V.A. Kosinov, E.A. Kulikov, D.V. Lobanov, Yu.A. Mitrofanova, V.V. Orlov, I.M. Petrov, R.V. Peshkov, S.A. Sidorov, S.A. Smirnov, E.I. Vorobiev, O.B. Yarovikova	
2.	**BM@N project** **Subproject SRC**	**M.N. Kapishin** **E. Piasetzki** **Deputies:** **O. Hen** **T. Aumann**	Realization
2.1.	**Development of the operational area of the setup: increasing the radiation protection, improving detector subsystems and engineering infrastructure**	**S.Yu. Anisimov** **M.N. Kapishin** **S.M. Piyadin**	Realization
2.2.	**Construction of the basic detector complex of the BM@N setup**	**M.N. Kapishin**	Realization
2.3.	**Development of the technological and engineering systems, control systems and test areas of the setup**	**S.Yu.Anisimov** **S.M. Piyadin** **N.D. Topilin**	Realization
	VBLHEP	H.U. Abraamyan, G.S. Averichev, G.N. Agakishiev, S.V. Afanasiev, S.Yu. Anisimov, V.A. Babkin, S.N. Bazylev, V.P. Balandin, A.E. Baskakov, P.N. Batyuk, V. Bekirov, D.N. Bogoslovsky, I.V. Boguslavsky, M.G. Buryakov, D. Dambrovski, A.V. Dmitriev, P.O. Dulov, D.K. Dryablov, B.V. Dubinchik, D.S. Egorov, E.S. Erin, Yu.I. Fedotov, Ya. Fedorishin, I.A. Filippov, O.P. Gavrischuk, P.S. Geraksiev, K.V. Gertsenberger, S.V. Gertsenberger, V.M. Golovatyuk, Z.A. Igamkulov, M.A. Ilieva, M.N. Kapishin, V.Yu. Karzhavin, V.N. Karpinsky, R.R. Kattabekov, G.D. Kekelidze, V.I. Kireev, Yu.T. Kiryushin, S.V. Khabarov, A.D. Kovalenko, V.Yu. Kozhin, E.S. Kokoulina, V.I. Kolesnikov, A.O. Kolesnikov, V.G. Krivokhizhin, I.V. Kruglova, A.S. Kuznetsov, N.A. Kuz'min, E.M. Kulish, S.N. Kukhlin, E.A. Ladygin, V.V. Lenivenko, A.N. Livanov, A.G. Litvinenko, S.N. Lobastov, 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, R.V. Nagdasev, S.N. Nagorny, D.N. Nikitin, V.A. Nikitin, V.F. Peresedov, V.A. Petrov, Yu.N. Petukhov, S.M. Piyadin, Yu.K. Potrebenikov, V.Yu. Rogov, K. Roslon, P.A. Rukoyatkin, M.M. Rumyantsev, A.D. Rustamov, I.A. Rufanov, D.G. Sakulin, S.V. Sergeev, V.O. Sidorenko, V.A. Sitnikov, V.N. Spaskov, E.A. Strokovsky, D.A. Suvarieva, I.V. Slepnev, V.M. Slepnev, I.P. Slepov, B.V. Sukhov, V. Sheynast, R.A. Shindin, A.V. Shutov, V.B. Shytov, A.V. Schipunov,	

		N.A. Tarasov, O.G. Tarasov, A.V. Terletsky, A.A. Timoshenko, V.V. Tikhomirov, N.D. Topilin, I.A. Tyapkin, V.V. Ustinov, V.A. Vasendina, S.E. Vasiliev, N.M. Vladimirova, L.S. Yordanova, V.I. Yurevich, G.A. Yarygin, N.I. Zamyatin, A.I. Zinchenko, E.V. Zubarev	
	LIT	D.A. Baranov, Zh.Zh. Musul'manbekov, V.V. Pal'chik, N.N. Voytishin	
	FLNP	E.I. Litvinenko	
2.4.	**Studies of Short-Range-Correlations of nucleons at BM@N (SRC)**	**M.N. Kapishin** **E. Piasetzky** **Deputies:** **O. Hen** **T. Aumann**	Realization
3.	**MPD setup**	**V.M. Golovatyuk** **V.D. Kekelidze**	R&D Technical proposal
	VBLHEP	H.U. Abraamyan, G.S. Averichev, A.V. Averiyanov, G.N. Agakishiev, T.V. Andreeva, A.B. Anisimov, V.A. Babkin, A.G. Bazhazhin, S.V. Bazylev, S.N. Bazylev, V.P. Balandin, A.E. Baskakov, P.N. Batyk, D.N. Bogoslovsky, M.G. Buryakov, V.V. Chepurnov, G.A. Cheremukhina, D.V. Dementiev, A.V. Dmitriev, I.I. Donguzov, Dzh. Drnoyan, P.O. Dulov, V.B. Dunin, V.V. Elsha, O.V. Fateev, Ya. Fedorishin, I.A. Filippov, O.P. Gavrischuk, I.V. Gapienko, P.S. Geraksiev, K.V. Gertsenberger, Yu.V. Gusakov, A.V. Ivanov, M.A. Ilieva, A.Yu. Isupov, G.D. Kekelidze, V.A. Kireev, Yu.T. Kiryushin, E.M. Kislov, S.V. Khabarov, M.A. Kozhin, E.V. Kostyukhov, N.A. Kuz'min, A.O. Kolesnikov, A.M. Korotkova, E.A. Ladygin, A.G. Litvinenko, V.I. Lobanov, S.N. Lobastov, Yu. Lukstin'sh, V.M. Lysan, D.T. Madigozhin, A.I. Malakhov, S.P. Merts, I.I. Migulina, S.A. Movchan, N.A. Molokanova, A.A. Mudrokh, Yu.A. Murin, V.V. Myalkovsky, R.V. Nagdasev, S.N. Nagorny, V.A. Nikitin, V.A. Penkin, V.F. Peresedov, V.A. Petrov, Yu.P. Petukhov, A.V. Pilyar, A.A. Povtoreyko, Yu.K. Potrebenikov, I.A. Polenkevich, S.V. Razin, O.V. Rogachevsky, V.Yu. Rogov, K. Roslon, M.M. Rumyantsev,A.D. Rustamov A.A.Rybakov, V.M. Samsonov, T.V. Semchukova, S.V. Sergeev, V.O. Sidorenko, I.P. Slepov, V.M. Slepnev, I.V. Slepnev, D.A. Suvarieva, A.D. Sheremetiev, S.N. Shkarovsky, V.I. Shokin, K. Shtejer, A.B. Shutov, N.A. Shutova, A.V.Schipunov, N.A. Tarasov, O.G. Tarasov, A.V. Terletsky, A.A. Timoshenko, V.V. Tikhomirov, I.A. Tyapkin, S.Yu. Udovenko, V.A. Vasendina, S.V. Vereschagin, A.V. Vishnevsky, S.V. Volgin, A.L. Voronin, V. Voronyuk, Y.M. Vladimirova, A.I. Yukaev, G.A. Yarygin, L.S. Yordanova, N.K. Zhidkov, S.A. Zaporozhets, N.A. Zinin, A.I. Zinchenko, D.A. Zinchenko, N.I. Zamyatin, V.N. Zryuev, A.N. Zubarev	
	DLNP	I.N. Meshkov, A.G. Ol'shevsky	
	LIT	P.G. Akishin, O.Yu. Derenovskaya, V.V. Ivanov, P.I. Kisel', Zh.Zh. Musul'manbekov, A.M. Raportirenko	

3.1.	**Design and construction of the superconducting solenoid and magnet yoke**	**N.E. Emelyanov** **N.D. Topilin**	R&D Technical proposal
	VBLHEP	V.H. Dodokhov, A.A. Efremov, N.E. Emelyanov, S.G. Gordeev, G.D. Kekelidze, E.M. Kislov, V.I. Lobanov, Yu.Yu. Lobanov, N.D. Topilin	
3.2.	**Construction of the detector complex of the start configuration of the MPD setup**	**V.M. Golovatyuk** **V.D. Kekelidze**	R&D Technical proposal
	VBLHEP	V.A. Babkin, C.N. Bazylev, S.A. Movchan, Yu.A. Myrin, I.A. Tyapkin, N.D. Topilin, V.I. Yurevich	
3.3.	**Design and creation of the data acquisition and control systems**	**S.N. Bazylev** **I.V. Slepnev**	R&D Technical proposal
	VBLHEP	A.E. Baskakov, A.A. Fedyunin, I.A. Filippov, S.N. Kuklin, V.M. Slepnev, N.A. Tarasov, A.V. Terletsky, A.B. Shutov, A.V. Schipunov	
3.4	**Development of MPD physical program**	**V.I. Kolesnikov** **A.I. Zinchenko**	Realization
4.	**Theoretical investigations, calculations and development of models descibling nuclear matter properties at high temperatures and compressions, dynamics of high–energy nuclear interactions at extremenly high baryonic densities, spin and P–odd effects**	**D. Blashke** **A.S. Sorin** **O.V. Teryaev**	Realization
	BLTP	A.V. Efremov, A. Frizen, A.S. Hvoroctukhin, S.B. Gerasimov, Ya.N. Klopot, A.G. Oganesyan, A. Parvan, M.K. Volkov	
	LIT	Yu.L. Kalinovsky, Zh.Zh. Musul'manbekov, E.G Nikonov	
	DLNP	G.I. Lykasov	
	VBLHEP	H.. Abraamyan, D.A. Artemenkov, P.N. Batyuk, D.K. Dryablov, V.D. Kekelidze, M.A. Kozhin, R. Lednický, A.G. Litvinenko, A.I. Malakhov, S.G. Reznikov, O.V. Rogachevsky, V. Voronyuk, V.N. Zhezher	
5.	**Computer infrastructure: on–line and off–line clusters of the distributed computer complex, system of simulation, data transfer and analysis, information and technological computer systems**	**A.G. Dolbilov** **Yu.K.Potrebenikov** **O.V. Rogachevsky**	Realization
	VBLHEP	V.F. Dydyshko, O.S. Fedoseev, D.G. Mel'nikov, Yu.I.Minaev, S.A. Mityukhin, D.V. Peshekhonov, I.P. Slepov, B.G. Schinov, I.V. Slepnev, S.N. Shkarovsky, V.L. Svalov	

	LIT	A.G. Dolbilov, D.V. Kekelidze, V.V. Koren'kov, M.S. Plyashkevich, T.A. Strizh	
6.	**SPD setup: conceptual design project development, international collaboration formation**	**R. Tsenov**	Project preparation
	VBLHEP	N.I. Azorsky, R.R. Akhunzyanov, V.A. Anosov, A.A. Baldin, M.Yu. Baranov, V.S. Batozskaya, A.N. Beloborodov, I.V. Boguslavsky, V.B. Dunin, Yu.N. Filatov, T.L. Enik, O.P. Gavrischuk, A.S. Galoyan, A.S. Gribovsky, V.A. Gromov, Yu.V. Gurchin, Yu.V. Gusakov, A.V. Ivanov, A.Yu. Isupov, G.D. Kekelidze, Yu.S. Kovalev, M.A. Kozhin, E.S. Kokoulina, A.O. Kolesnikov, E.V. Kostyukhov, Yu.A. Kopylov, V.A. Kramarenko, V.N. Kruglov, S.V. Khabarov, P.R. Kharyuzov, A.N. Khrenov, I.V. Lapshina, V.P. Ladygin, V.M. Lysan, R. Lednický, A.M. Makan'kin, G.V. Mescheryakov, I.V. Moshkovsky, A.P. Nagaytsev, V.A. Nikitin, V.V. Pavlov, S.S. Parzhitsky, E.E. Perepelkin, D.V. Peshekhonov, S.G. Reznukov, O.V. Rogachevsky, I.A. Savin, A.A. Savenkov, S.Yu. Starikova, E.A. Strokovsky, Ya.T. Skhomenko, E.A. Streletskaya, O.G. Tarasov, O.V. Teryaev, A.V. Tishevsky, N.D. Topilin, B.L. Topko, E.A. Usenko, A.I. Sheremetieva, S.S. Shimansky, E.V. Vasilieva, N.I. Veselova, P.V. Volkov, I.P. Yudin, N.I. Zamyatin, I.A. Zhukov, E.V. Zemlyanichkina, A.V. Zinin, E.V. Zubarev	
	DLNP	V.M. Abazov, G.D. Alexeev, L.G. Afanasiev, A.V. Bobkov, I.I. Denisenko, V.N. Duginov, G.A. Golovanov, K.I. Gritsay, A.V. Gus'kov, M. Finger, M. Finger(younger), V.N. Frolov, A.V. Kulikov, S.A. Kutuzov, Yu.A. Nefyedov, A.A. Piskun, I.K. Prokhorov, V.M. Romanov, A.I. Rudenko, A. Rymbekova, A.G. Samartsev, A.V. Semenov, N.B. Skatchkov, M. Slunečhka, V. Slunečhkova, A.V. Tkatchenko, V.V. Tokmenin, Yu.N. Uzikov, L.S. Vertogradov, A.Yu. Verkheev, N.I. Zhuravlev	
	LIT	V.V. Uzhinsky, R.V. Polyakova	
	BLTP	I.V. Anikin, A.V. Efremov, S.V. Goloskokov, Yu. Klopot, D. Strizhik, N.I. Volchansky	
7.	**Construction of the complex of buildings with engineering infrastructure for object placement, engineering systems and carrying out R&D for the NICA complex**	**N.N. Agapov** **V.D. Kekelidze** **N.D. Topilin**	Projecting Realization
7.1.	**Technical designing, coordination of the construction of the building complex and engineering infrastructure development**	**A.V. Dudarev** **I.N. Meshkov**	Projecting Realization

7.2. **R&D, production of prototypes and full–scale superconducting magnets for the NICA booster and collider**	**H.G. Khodzhibagiyan** **S.A. Kostromin**	Projecting Realization	
VBLHEP	V.V. Agapova, A.S. Averichev, V.K. Alexeev, A.M. Bazanov, N.P. Bazylev, V.I. Batin, N.A. Blinov, Yu.T. Borzunov, V.V. Borisov, A.V. Butenko, A.V. Bychkov, S.A. Dolgy, A.M. Donyagin, V.M. Drobin, N.A. Filippov, E.Yu. Filippova, A.R. Galimov, O.M. Golubitsky, Yu.V. Gusakov, E.Yu. Ivanenko, V.N. Karpinsky, R.A. Karpunin, I.E. Karpunina, H.G. Khodzhibagiyan, S.Yu. Kolesnikov, A.V. Konstantinov, V.S. Korolev, S.A. Kostromin, A.V. Kudashkin, G.L. Kuznetsov, E.A. Kulikov, O.A. Kunchenko, V.E. Kurinov, V.I. Lipchenko, D.V. Lobanov, A.A. Makarov, Yu.A. Mitrofanova, A.Yu. Merkur'ev, A.V. Nesterov, A.L. Osipenkov, R.V. Pivin, D.O. Ponkin, T.F. Prakhova, A.S. Sergeev, A.V. Smirnov, S.A. Smirnov, A.Yu. Starikov, V.N. Surikov, A.V. Shabunov, E.V. Shevtchenko, Yu.A. Tumanova, A.S. Vinogradov, N.A. Zhil'tsova		
7.3. **Upgrade and development of electric power and technological nets aimed at the increasing of economics and technical efficiency**	**N.N.Agapov** **N.V. Semin**	Projecting Realization	
VBLHEP	A.V. Alfeev, A.M. Karetnik, A.A. Makarov, M.I. Migulin, E.V. Serochkin, V.M. Stepanov, A.N. Sotnikov, A.V. Shabunov, V.Yu. Shilov, O.M. Timoshenko, N.D. Topilin, V.P. Tchernyaev		
AS&CC Office	Yu.N. Balandin, I.S. Frolov, L.I. Tikhomirov		
OCE	V.N. Buchnev, 2 pers.		
LRB	G.N. Timoshenko, 3 pers.		

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	GSTU
Bulgaria	Sofia	INRNE BAS
		ISSP BAS

		TU-Sofia
		LTD BAS
	Blagoevgrad	SWU
	Plovdiv	PU
CERN	Geneva	CERN
China	Beijing	"Tsinghua"
	Hefei	USTC
		IPP CAS
	Huzhou	HU
	Lanzhou	IMP CAS
	Yichang	CTGU
	Wuhan	CCNU
Chile	Valparaiso	UTFSM
Czech Republic	Liberec	TUL
	Prague	CU
	Vitkovice	VHM
France	Nantes	SUBATECH
Egypt	Cairo	ECTP
Germany	Darmstadt	GSI
		TU Darmstadt
	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
		INFN
	Brescia	Forgiatura Morandini
	Genova	ASG
Israel	Tel Aviv	TAU
	Jerusalem	HUJI
Mexico	Mexico	UNAM
	Puebla	BUAP
Moldova	Chişinău	MSU
		IAP ASM
Mongolia	Ulaanbaatar	IPT MAS
Poland	Chorzow	Frako-Term
	Warsaw	WUT

	Wroclaw	ILT&SR PAS
	Lublin	UMCS
	Otwock-Swierk	NCBJ
Romania	Bucharest	INOE2000
		IFIN-HH
		INCDIE ICPE-CA
Russia	Moscow	LPI RAS
		ITEP
		LPI RAS
		MSU
		Cryogenmash
		Geliymash
		NRC KI
		NNRU "MEPhI"
		IBMP RAS
	Moscow, Troitsk	INR RAS
	Belgorod	BelSU
	Gatchina	NRC KI PNPI
	Dubna	PELCOM
		Progresstech
	Kazan	Compressormash
		Spetshmash
	Novosibirsk	BINP SB RAS
		STL "Zaryad"
	Protvino	IHEP
	St. Petersburg	Neva-Magnet
		KRI
		SPbSU
	Syktyvkar	DM Komi SC UrB RAS
	Tomsk	NPI TPU
		TPU
		TSU
	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
		NSC KIPT

		LTU
USA	Batavia, IL	Fermilab
	Upton, NY	BNL
	Stony Brook, NY	SUNY

02–0–1127–2016/2023	Priority: 1
	Status: Extended

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, CERN, Germany, Georgia, Italy, Russia, Slovakia.

Issues addressed and main goals of research:

Creation of the NETWORK of 6 Precision Laser Inclinometers (PLI), creation of the prototype of Amplitude Interferometric Distance Meter for the length of 16 m, creation of the prototype of Laser Fiducial Line for the length of 150 m, creation of the prototype of Seismically-stabilized Research Platform based on PLI. Investigation of the various carbon-based transmission photocathodes (mainly carbon-based), installation of the second beamline with the 213 nm laser at the photogun bench, development of the photoinjector bench: 150 KeV electron energy achievement, development of the radiation safety, interlock and control systems. Development, design parameters achievement and commissioning of the LINAC-200 linear electron accelerator with the aim of its experimental and education applications. Optimization of the accelerator parameters for users. Maintenance of the FLASH infrared undulator and participation in its experimental program, as well as in the new undulator development; development of photon diagnostic for FLASH, FLASH2 and XFEL and experiments participation. Experimental investigations at formation of 3D ellipsoidal shape electron bunches with small emittances in PITZ with new laser system. Preparation of the proposals and start of the JINR participation in international collaborations for future high-energy colliders.

Expected major results in the current year:

- Study of the photocathodes based on extremely thin hybrid carbon films, influence of the films composition and diamond/graphite phases ratio on the quantum efficiency ($\lambda = 266$ nm). Study of the possibility of the quantum efficiency rising due to the laser beam reflected from the photocathode. Installation of the second beamline with the 213 nm laser at the photogun bench. Photoinjector bench startup with 150 KeV energy.

- Optimization of the Linac-200 beam parameters at 200 MeV energy. Modernization of the 3rd accelerating station cooling system. Extraction of the beam with wide range parameters from single electrons up to 30 mA with repletion rate up to 25 Hz into the atmosphere, optimization of beam parameters for users. Manufacturing of beam parallel transfer system (LNP program) after 2nd and 3rd accelerating stations. Work on reconstruction and modernization of the control and interlock systems.

- Microseismic activity measurements at the CERN and GGO and estimate of the microseisms influence on the LHC luminosity; development of the Technical Assignement on the modernisation of the professional (PLI) hard a soft basement. Designing and construction of prototype of Absolute Distance Meter with 1 μm 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 μm precision (the nondestructive control).

- 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 proposals and start of the JINR participation in international collaborations for future high-energy colliders.

List of projects:

Project	Leader	Priority (period of realization)
1. The precision laser metrology for accelerators and detector complexes	Yu.A. Budagov	2 (2016 – 2021)

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **Photoinjecting systems R&D**	**N.I. Balalykin** **M.A. Nozdrin**	Technical proposal Realization
VBLHEP	V.F. Minashkin, V.G. Shabratov, A.V. Shevelkin	
2. **LINAC-200 electron accelerator**	**G.D. Shirkov** **V.V. Kobets**	Technical proposal Realization
VBLHEP	V.F. Minashkin, M.A. Nozdrin, A.S. Sledneva	
DLNP	E.M. Acosta, A.E. Brukva, A.S. Dyatlov, N.I. Garanzha, V.D. Korovyakov, A.V. Skrypnik, A.G. Sorokin, V.G. Shabratov, D.S. Shokin	
UC	D.S. Belozerov, K.B. Gikal, S.Z. Pakulyak, K.A. Verlamov, D.A. Zlydenny, A.S. Zhemchugov	
3. **The precision laser metrology for accelerators and detector complexes**	**J.A. Budagov** **M.V. Lyablin**	Technical proposal Realization
DLNP	N.S. Azaryan, T.I. Azaryan, I.V. Bednyakov, Yu.I. Davidov, V.V. Glagolev, V.I. Kolomoets, S.M. Kolomoets, A.A. Pluzhnikov, A.V. Sazonova, S.N. Studenov, G.T. Torosyan	
GA&C	G.V. Trubnikov	
4. **Free electron lasers R&D**	**E.M. Syresin** **O.I. Brovko** **M.V. Yurkov**	Technical proposal Realization
UC	A.F. Chesnov, N.A. Morozov, D.C. Petrov	
5. **Preparation of the proposals and start of the JINR participation in international collaborations for future high-energy colliders**	**G.D. Shirkov** **A.D. Kovalenko**	Preparation

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Garni	GGO
	Yerevan	Shirak Technologies
Belarus	Minsk	INP BSU
CERN	Geneva	CERN
Germany	Hamburg	DESY
Georgia	Tbilisi	HEPI-TSU
Italy	Pisa	INFN
Russia	Nizhny Novgorod	IAP RAS
Slovakia	Bratislava	IEE SAS

02–1–1097–2010/2021	Priority: 1
	Status: Extended

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:

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

Issues addressed and main goals of research:

Development of the infrastructure for spin physics research at the Nuclotron–M/NICA and other facilities. Preparation of the spin control and polarimetry system projects. Measurement of analyzing power in the reaction of polarized protons and polarized neutrons with polyethylene target at the momentum up to 7.5 GeV/c and up to 6.0 GeV/c for polarized proton and neutron respectively at the setup ALPOM–2. Study of 2N– and 3N–correlations in deuteron–proton elastic scattering and deuteron break–up reactions at the Nuclotron internal target. Measurement of the cross sections and deuteron analyzing powers of the reactions. Completion of the data analysis obtained at the setup Delta–Sigma. Preparation of the proposals on modernization of the spectrometer and the Saclay–Argonne–JINR polarized proton target (setup PPT). Obtained new data on the studying of charge–exchange processes in the interactions of polarized deuterons and protons 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. Works on the program of the setup DELTA–2 design INR RAN/JINR.

Expected major results in the current year:

- Works:
  a) project of low energy proton and deuteron polarimeter at the Nuclotron injection channel;
  b) project of high energy proton and deuteron polarimeter for the NICA complex.
- Fulfilment of the works in accordance with the approved projects and collaborative protocols within the frames of their real financial support, including realization of the projects ALPOM–2 abd DSS.
- Participation in the development of the BM@N setup elements in accordance with general plan.
- Participation in the joint scientific programs and experiments, design and test of the new detectors elements at the other facilities SPS, LHC, FCC (CERN), RHIC (BNL), MEIC (TJNAF), 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 – 2021)
2. DSS	V.P. Ladygin M. Janek K. Sekiguchi	1 (2010 – 2021)

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **Development of spin physics research in frastructure at the Nuclotron and other facilities. Design, construction and development of spin control and polarimetry systems**	**A.D. Kovalenko**	Realization
VBLHEP	A.V. Averyanov, Yu.N. Filatov, V.V. Fimushkin, V.V. Glagolev, D.O. Krivenkov, R.A. Kuzyakin, M.V. Kulikov, V.P. Ladygin, K.S. Legostaeva, A.N. Livanov, S.V. Novozhilov, N.M. Piskunov, S.G. Reznikov, R.A. Shindin, E.A. Strokovsky, A.M. Taratin	
DLNP	M. Finger, M. Finger (Jr.), Yu.N. Uzikov	
LIT	R.V. Polyakova	
2. **ALPOM-2 Project**	**N.M. Piskunov**	Data taking
VBLHEP	S.N. Bazylev, Yu.P. Bushuev, O.P. Gavrishchuk, V.V. Glagolev, A.N. Ivanov, D.A. Kirillov, A.D. Kovalenko, A.A. Povtoreyko, P.A. Rukoyatkin, I.M. Sitnik	
3. **DSS Project**	**V.P. Ladygin** **M. Janek** **K. Sekiguchi**	Preparation Data taking
VBLHEP	E.V. Chernykh, Yu.V. Gurchin, A.Yu. Isupov, A.N. Khrenov, N.B. Ladygina, A.N. Livanov, S.G. Reznikov, Ya.T. Skhomenko, A.A. Terekhin, A.V. Tishevsky, I.S. Volkov	
DLNP	G.I. Lykasov	
4. **Delta–Sigma setup**	**R.A. Shindin**	Data analysis Project preparation
VBLHEP	Yu.T. Borzunov, E.V. Chernykh, I.P. Yudin	
DLNP	N.S. Borisov, E.I. Bunyatova, M. Finger, M. Finger (Jr.), M. Slunečhka, V. Slunečhkova, Yu.A. Usov	
FLNP	S.B. Borzakov	
BLTP	N.V. Kochelev	

5. **Experiments on the program STRELA at polarized beam**	**N.M. Piskunov**	Data taking
VBLHEP	S.N. Bazylev, Yu.P. Bushuev, V.V. Glagolev, D.A. Kirillov, A.A. Povtoreyko, I.M. Sitnik	
6. **Theoretical calculations of polarized processes**	**V.V. Burov** **V.K. Lukyanov**	Data analysis
BLTP	V.V. Burov	
VBLHEP	N.B. Ladygina, A.P. Ierusalimov	
7. **Spin effects in hadron-nucleon and lepton-nucleon interactions**	**M. Finger(Jr.)**	Data analysis
DLNP	E.I. Bunyatova, M. Finger, M. Slunečhka, V. Slunečhkova	
8. **Works on the program DELTA–2 (INR RAS - JINR)**	**A.B. Kurepin** **A.N. Livanov**	Preparation Data taking
VBLHEP	Yu.S. Anisimov, S.N. Bazylev, A.P. Ierusalimov, V.P. Ladygin, S.M. Piyadin	

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Bulgaria	Sofia	UCTM
CERN	Geneva	CERN
Czech Republic	Prague	CU
		CTU
	Brno	ISI CAS
	Liberec	TUL
	Řež	UJV
France	Saclay	IRFU
	Orsay	IPN Orsay
Germany	Dresden	TU Dresden
	Bochum	RUB
	Tübingen	Univ.
	Freiburg	Univ.
	Jülich	FZJ
Japan	Tokyo	UT
	Hiroshima	Hiroshima Univ.
	Osaka	RCNP
Poland	Otwock-Swierk	NCBJ
Romania	Bucharest	INCDIE ICPE-CA
Russia	Gatchina	NRC KI PNPI
	Moscow	LPI RAS
		NRC KI
	Moscow, Troitsk	INR RAS
		LPP LPI RAS

Slovakia	Bratislava	IP SAS
	Košice	IEP SAS
		PJSU
	Žilina	UŽ
Sweden	Uppsala	TSL
Switzerland	Geneva	UniGe
	Villigen	PSI
Ukraine	Kharkov	NSC KIPT
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

02–1–1087–2009/2020	Priority: 1
	Status: In-progress

Research on Relativistic Heavy and Light Ion Physics. Experiments at the Accelerator Complex Nuclotron/NICA at JINR and CERN SPS

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

Participating countries and international organizations:

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

Issues addressed and main goals of research:

The study of new phenomena in multiple particles productions associated with the manifestation of the quark and gluon degrees of freedom in the interaction of relativistic nuclei. The study of nucleon and nuclear interactions in the VBLHEP accelerator complex, CERN SPS. Energy scan of interactions of nuclei at energies 20–158 GeV/-nucleon and to study their dependence on the atomic number of nuclei. The searching of the critical point on the phase diagram of nuclear matter on the NA61(SPS, CERN). Study of hadron production in hadron–nucleus interactions. The use of obtained data for precision calculations of spectra and fluxes in accelerator neutrino experiments to study neutrino oscillations. The study of claster structures in light stable and radioactive nuclei in the relativistic dissociation. A study of the multiple fragmentation of heavy nuclei. Experimental and theoretical study of deep subthreshold, cumulative processes, the formation of hadrons and antimatter in the transition energy region. A study of the behaviour of elementary particles, nucleon resonances and nucleon fluctuations in nuclear matter on the spectrometer SCAN. Preparation of proposaps of experiments at the accelerator complex of VBLHEP on the extracted beams of the Nuclotron and NICA Collider. Study of the short range nucleon–nucleo correlations and cluster structure of the nuclei using the beams of ions, polarized protons and deuterons at the internal target of Nuclotron in the framework of DSS and SCAN–3 projects.

Expected major results in the current year:

- The continuation of experiments at the internal target of the Nuclotron. Preparation and execution of the experiments at the extracted beam of the Nuclotron. The development of simulations and processing of experimental data.
- Processing and analysis of experimental data obtained at the instalation NA61/SHINE (SPS, CERN) for p+p, Be+Be, Ar+Sc, Pb+Pb collisions. Preparation and implementation of experimental studies on the relativistic beam of lead nuclei. Study of the formation of anti–nuclei in the Ar+Ca and Xe+La collisions.
- Configure and test three–arms magnetic spectrometer SCAN. The modernization of electronics for data taken. The analysis of experimental data.
- Upgrading the trigger system for the PHASE setup. Analysis of experimental data within the statistical and dynamic models. The perparation of a new project.
- An analysis of data from bubble chambers to search and investigate new phenomena on the basis of the supercomputer LIT JINR. Extension of the experimental database in the field of relativistic nuclear physics.
- Complete reconstruction of the experimental zone of the channel–spectrometer 7B of the MARUSYA setup. Creation and commissioning of coordinate and Cherenkov detectors. Reconstruction of the target station with placment of the target in a vacuum. Development, creation and testing of a neutron detector. Elaboration of the physics program and preparation of a new project MARUSYA–FLINT in the development of the experimental setup MARUSYA.

- Adaptation of MARUSYA setup for testing detectors of the experiments at the collider NICA.
- Preparation of technical project for the measurement of the luminosity at the collider NICA.
- Preparation of a proposal to study the structure of short–range nucleon–nucleon correlations on the internal target and extracted beam of the Nuclotron.

List of projects:

Project	Leader	Priority (period of realization)
1. NA61	A.I. Malakhov	2 (2012 – 2021)
2. SKAN-3	S.V. Afanasiev	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**	Upgrade Preparation Data analysis
VBLHEP	V.A. Babkin, M.G.Buryakov, V.I. Kolesnikov, V.A. Kireev, V.A. Lenivenko, V.A. Matveev M.M. Rumyantsev, A.A. Zajtsev	
DLNP	V.V. Lyubushkin, G.I. Lykasov, B.A. Popov, V.V. Tereschenko	
2. **Experiment BECQUEREL**	**P.I. Zarubin**	Data taking Data analysis
VBLHEP	D.A. Artemenkov, V. Bradnova, N.K. Kornegrutsa, V.V. Rusakova, P.A. Rukoyatkin, A.A. Zaytsev	
3. **Experiment FASA-3**	**S.P. Avdeev**	Upgrade Preparation Data analysis
DLNP	V.I. Stegaylov	
FLNR	V.V. Kirakosyan, 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 analysis Upgrade
VBLHEP	Yu.S. Anisimov, A.A. Baldin, A.V. Beloborodov, V. Bekirov, D.K. Dryablov, B.V. Dubinchik, A.F. Elishev, Z.A. Igamkulov, L.V. Kornyushina, Yu.F. Krechetov, A.S. Kuznetsov, S.N. Kuznetsov, M. Paraypan, D.G. Sakulin, V.A. Smirnov, E.V. Sukhov, V.V Ustinov, P.R. Kharyuzov	
DLNP	A.N.Fedorov	

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

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

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, S.N. Bazylev, A.I. Berlev, D.K. Dryablov, E.A. Efimova, A.V. Feschenko, I.V. Kudashkin, E.A. Levterova, R.A. Salmin, S.Yu. Starikova, I.V. Slepnev, S.G. Stetsenko, T.V. Shavrina, S.S. Shimansky, A.Yu. Troyan, I.P. Yudin

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.A. Baldin, E.G. Baldina, D.K. Dryablov, A.D. Kovalenko, M. Paraypan

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

S.V. Afanasiev

Upgrade
Data taking

VBLHEP

Yu.S. Anisimov, V.N. Bekirov, D.K. Dryablov, B.V. Dubinchik, A.F. Elishev, Z.A. Igamkulov, 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

R&D
Technical proposal

VBLHEP

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

FLNP

E.I. Litvinenko

10. **Study of the short range nucleon–nucleon correlations at modernized internal target station at Nuclotron**

V.P. Ladygin

Preparation
Data taking

VBLHEP

Yu.V. Gurchin, A.Yu. Isupov, P.K. Kurilkin, A.N. Khrenov, N.B. Ladygina, A.I. Malakhov, S.G. Reznikov, Ya.T. Schomenko, A.A. Terekhin, A.V. Tishevsky

Collaboration

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

	Moscow, Troitsk	INR RAS
	Vladikavraz	VTC "Baspik"
	Chernogolovka	ISMAN RAS
	Protvino	IHEP
	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

02–0–1066–2007/2020	Priority: 1

Status: In-progress

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.

Issues addressed and main goals of research:

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 major results in the current year:

- The data on heavy ion isobaric collisions (Zr–96, Ru–96).
- The data on global polarization in gold–gold collisions at 27 GeV.
- 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. Development of JINR educational portal.

List of projects:

Project	Leader	Priority (period of realization)
1. STAR	Yu.A. Panebratsev R. Lednický	1 (2010 – 2021)

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**	**Yu.A. Panebratsev**	Data taking Data analysis
VBLHEP	D.N. Bogoslovsky, T.G. Dedovich, V.B. Dunin, A.O. Kechechyan, A.A. Povtoreyko, V.Yu. Rogov, S.V. Sergeev, V.V. Tikhomirov, M.V. Tokarev, V.I. Yurevich, G.A. Yarygin, A.N. Zubarev	

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

Collaboration

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

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

02–1–1088–2009/2019	Priority: 1

Status: Being concluded

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

Leader: A.S. Vodopyanov

Participating countries and international organizations:

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

Issues addressed and main goals of research:

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 major results in the current year:

- 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 – 2019)

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, A.G. Fedunov, S.S. Grigoryan, A.V. Kuznetsov, L.V. Malinina, K.P. Mikhaylov, V.N. Pozdnyakov, E.P. Rogochaya, K. Roslon, V.D. Rumyantsev, Yu.L. Vertogradova	
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
VBLHEP	B.V. Batyunya, A.G. Fedunov, G.G. Stiforov	
LIT	A.O. Kondratiev, V.V. Mitsyn	
4. **Photon Spectrometer PHOS**	**A.S. Vodopyanov** **P.V. Nomokonov**	Realization
VBLHEP	N.V. Gorbunov, N.A. Kuzmin, A.V. Kuznetsov, Yu.P. Petukhov, S.A. Rufanov	

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Armenia	Yerevan	Foundation ANSL
Azerbaijan	Baku	NNRC
Brazil	Porto Alegre, RS	UFRGS
Bulgaria	Sofia	SU
CERN	Geneva	CERN
China	Beijing	CIAE
	Wuhan	CCNU
Croatia	Zagreb	RBI
Czech Republic	Prague	IP CAS
	Řež	UJV
Denmark	Copenhagen	NBI
Finland	Helsinki	HIP
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	WWU
Greece	Athens	UoA
Hungary	Budapest	Wigner RCP
India	Aligarh	AMU
	Bhubaneswar	IOP
	Kolkata	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	NRC KI 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
Ukraine	Kharkov	NSC KIPT
	Kiev	BITP NASU
United Kingdom	Birmingham	Univ.
USA	Columbus, OH	OSU
	Oak Ridge, TN	ORNL

02–1–1107–2011/2019	Priority: 1

Status: Being concluded

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, Moldova, Mongolia, Poland, Romania, Russia, Slovakia, Ukraine.

Issues addressed and main goals of research:

Investigation of various subcritical setups and using them for energy prodution and radioactive waste transmutation, research of radiation hardness of materials. The quasi–infinite target (Project E&T&RM)

Expected main results:

- Receiving data about the multiplicities and special istribution of energy–time neutron spectra. Research on massive targets of natural (depleted) uranium and thorium energy production capabilities and processing of radioactive waste, the study of radiation hardness of superconductors by the beams of neutrons and protons.

Expected major results in the current year:

- Installation of a big uranium target on Phazotron in DLNP, beam adjustment on the target.
- Thermocouple device installation and callibration at the massive uranium target "BURAN".
- Pilot operation of the nutron spectrometer on recoil protons on the "BURAN" under irradiation with protons at Phazotron.
- Investigation of neutron leakage from the surface of the massive uranium target by activation method.
- Investigation of impact of high–power laser radiation on the radioactive decay of minor actinides.
- The investigation of radiation detects in high–temperature superconductors under the irradiation with protons with energy E = 660 MeV.

List of projects:

Project	Leader	Priority (period of realization)
1. Project E&T&RM	S.I. Tyutyunnikov	1 (2018 – 2019)

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	
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**	**S.I. Tyutyunnikov** **A.A. Solnyshkin** **A.A. Baldin,** **Z. Sadygov**	Realization
	VBLHEP	A.I. Berlev, I.P. Yudin	
3.	**Design, manufacture of detectors for the measurement of ion energy in the range of Ee=0.1 Gev/nucleon on the Nuclotron–M beams**	**N.I. Zamyatin**	Realization
	VBLHEP	S.V. Khabarov, Yu.S. Kovalev, O.G. Tarasov	
4.	**Upgrade of spectrum–analitical complex for activation measurements.**	**V.N. Shalyapin** **I.P. Yudin**	Realization
	VBLHEP	I.A. Kryachko, M. Paraipan, E.V. Strekalovskaya	
	DLNP	V.I. Stegaylov	
5.	**The study of neutron fields of big uranium target at the Phazotron under the irradiation of proton Ep=0.66 GeV**	**S.I. Tyutyunnikov** **A.A. Solnyshkin** **G.I. Smirnov** **M.Paraipan**	Data taking
	VBLHEP	A.I. Berlev, A.A. Baldin, T.L. Enik, A.V. Vishnesky, I.P. Yudin	
	DLNP	V.I. Stegaylov	
6.	**Production of the monitoring elements for the superconducting systems**	**Yu.P. Filippov**	R&D

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	YSU
Australia	Sydney	Univ.
Belarus	Minsk	INP BSU
		JIPNR-Sosny
		NASB
		RI PCP BSU
Bulgaria	Sofia	INRNE BAS
Czech Republic	Řež	UJV
	Brno	BUT
	Prague	CTU
Moldova	Chişinău	IAP ASM
Mongolia	Ulaanbaatar	IPT MAS
Poland	Warsaw	WUT

	Krakow	NINP PAS
	Otwock-Swierk	NCBJ
Russia	Dubna	BSINP MSU
		IAS "Omega"
	St. Petersburg	KRI
	Tomsk	TPU
Romania	Bucharest	ISS
		UMF
		IFIN-HH
	Baia Mare	TUCN-NUCBM
	Timişoara	UVT
Slovakia	Bratislava	SOSMT
		IP SAS
		CU
Ukraine	Kharkov	NSC KIPT

Nuclear Physics (03)

03–0-1129-2017/2021	Priority: 1

Status: In-progress

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

Leaders: G.G. Gulbekyan
S.N. Dmitriev
M.G. Itkis

Scientific leader: 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.

Issues addressed and main goals of research:

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 set-ups), and the development of the accelerator systems. The project leads to an increase in the operation stability of the accelerators, to 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 to an improvement of the quality of the beams with a simultaneous reduction of power consumption. The project aims at significantly improving 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.

Expected major results in the current year:

- Experiments at the Superheavy Element Factory (SHE Factory) to determine the optimum parameters for the new gas-filled separator of nuclear reaction products DGRFS-2.
- Extraction of beams of accelerated heavy ions at the SHE Factory. Preparation for experiments on the synthesis of a new element 119.
- Construction of a pre-separator for radiochemical studies of SHE – a new gas-filled recoil separator DGFRS-3.
- Experiments at the new ACCULINNA-2 fragment separator (U-400M cyclotron) using beams of light ions with the energies of 30 to 50 MeV/nucleon. Development of the infrastructure of the ACCULINNA-2 fragment separator (RF-kicker).
- Commissioning of works on upgrading the U-400M cyclotron.
- Development of the U-400 (U-400R) project that targets the construction of an experimental hall.
- Implementation of the experimental programme on the synthesis and study of superheavy nuclei and on the spectroscopy of heavy nuclei at the U-400 cyclotron.
- Development of new methods for beam diagnostics of stable and radioactive nuclides.
- Construction of a new gas-cell-based laser ionization set-up (GALS) for on-line separation of reaction products by selective laser ionization.
- Development of the high-resolution magnetic analyzer MAVR (equipped with a detecting device) and first experiments with heavy-ion beams. 11
- Preparation of technical assignments for the manufacture of separate nodes of the gas ion catcher and manufacture order placement.

List of activities:

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

6. **Development of a new gas-filled separator DGFRS-2** — **V.K. Utyonkov** — Preparation, Data taking

FLNR: F.Sh. Abdullin, N.D. Kovrijnykh, T.Sh. Mirsaitov, A.N. Polyakov, O.V. Petrushkin, R.N. Sagaidak, V.G. Subbotin, A.M. Sukhov, I.V. Shirokovsky, M.V. Shumeiko, A.S. Sviridchenkov, L. Schlattauer, Yu.S. Tsyganov, A.A. Voinov, A.N. Zubarev, A.M. Zubareva

7. **Construction of the DGFRS-3 pre-separator for radiochemical studies of SHE** — **A.G. Popeko**, **A.V. Eremin** — Preparation

FLNR: O.N. Malyshev, Yu.A. Popov, A.I. Svirikhin

8. **Construction of the gas catcher** — **A.M. Rodin** — Preparation

FLNR: A.V. Guljaev, A.V. Guljaeva, L. Krupa, A.B. Komarov, A.C. Novoselov, V.S. Salamatin, S.V. Stepantsov, V.Yu. Vedeneev, S.A. Yukhimchuk

9. **Development of a separator based on resonance laser ionization** — **S.G. Zemlyanoy** — Preparation

FLNR: K.A. Avvakumov, E.M. Kozulin, G.V. Myshinskiy, V.I. Zhemenik, B. Zuzaan

Collaboration

Country or International Organization	City	Institute or Laboratory
Belgium	Leuven	KU Leuven
	Louvain-la-Neuve	IBA
Bulgaria	Sofia	INRNE BAS
CERN	Geneva	CERN
China	Lanzhou	IMP CAS
Czech Republic	Prague	CTU
		CU
		VP
	Brno	BUT
	Řež	NPI CAS
	Štěnovice	STREICHER
Egypt	Shibin El Kom	MU
	Giza	CU
France	Caen	GANIL
	Vannes	SigmaPhi
Germany	Darmstadt	GSI
	Heidelberg	MPIK
Italy	Catania	INFN LNS
Kazakhstan	Almaty	INP
	Astana	BA INP

Mongolia	Ulaanbaatar	NRC NUM
Poland	Krakow	NINP PAS
	Warsaw	HIL WU
		IEP WU
Romania	Bucharest	IFIN-HH
		N&V
Russia	Moscow	HTDC
		ITT-Group
		ITEP
	Gatchina	NRC KI PNPI
	Nizhny Novgorod	IAP RAS
	Novosibirsk	BINP SB RAS
	Sarov	VNIIEF
	St. Petersburg	NIIEFA
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

03–5-1130-2017/2021	Priority: 1
	Status: In-progress

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, Egypt, Finland, France, Germany, India, Italy, Japan, Kazakhstan, Mongolia, Poland, Romania, Russia, Slovakia, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, USA, Vietnam.

Issues addressed and main goals of research:

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

Expected major results in the current year:

- Experiments for studying complete fusion reactions with ^{50}Ti.
- Preparing for and conducting first test experiments on the synthesis of isotopes of element 115 (Mc) in the ^{48}Ca + ^{243}Am reaction at the SHE Factory.
- Experiments on the measurement of the multiplicity of prompt neutrons from the spontaneous fission of Sg isotopes in the reactions with ^{54}Cr and heavy isotopes of Rf in the reactions with ^{22}Ne. Searching for rare reaction channels with the evaporation of charged particles, studying the decay properties of heavy Rf and Sg isotopes using the separator SHELS + GABRIELA. Preparation for experiments on the spectroscopy studies of the decay properties of the ^{288}Mc nuclide and its daughter products.
- Experiments on the study of the chemical properties of element 113 in the ^{48}Ca + ^{243}Am reaction. Preparation for experiments aimed to study the chemistry of SHE at the SHE Factory.
- Measurements of the cross-sections of xn channels for the complete fusion reactions ^{40}Ar+^{144}Sm, ^{40}Ar+^{164}Er, ^{40}Ca+^{144}Nd, and ^{48}Ca+^{142}Nd.
- Investigation of the mass-energy distributions of fragments produced in the reactions ^{18}O+^{232}Th,^{238}U, ^{22}Ne+^{232}Th,^{238}U, and ^{48}Ca+^{154}Sm. Study of multi-body decays of low-excited heavy nuclei. Study of multicluster decay of heavy and superheavy nuclei. Development of physics set-ups.
- Investigation of the structure of the exotic nuclei ^{7}H, ^{17}Ne, and ^{26}Si using radioactive beams at the ACCULINNA-1 and ACCULINNA-2 set-ups.
- Experiments with the ^{16}O and ^{22}Ne heavy-ion beams. Measurement of yields of multi-nucleon transfer reaction products. Measurement of total reaction cross-sections and those of individual channels using high-efficiency methods for registration and identification of products with low-intensity beams of exotic nuclei (10^3-10^5 s^{-1}).
- 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.

List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. **Synthesis of new isotopes of superheavy elements at DGFRS**	**V.K. Utyonkov**	Data taking
FLNR	F.Sh. Abdullin, N.D. Kovrijnykh, D.A. Kuznetsov, A.N. Polyakov, O.V. Petrushkin, R.N. Sagaidak, V.G. Subbotin, A.M. Sukhov, I.V. Shirokovsky, M.V. Shumeiko, A.S. Sviridchenkov, D.I. Solov'ev, L. Schlattauer, Yu.S. Tsyganov, A.A. Voinov, A.M. Zubareva	
2. **α-, β- and γ- spectroscopy of heavy nuclei at the SHELS separator**	**A.V. Yeremin**	Data taking
FLNR	V.I. Chepigin, M.L. Chelnokov, A.V. Isaev, I.N. Izosimov, D.E. Katrasev, A.N. Kuznetsov, A.A. Kuznetsova, O.N. Malyshev, Yu.A. Popov, V.M. Popov, A.G. Popeko, E.A. Sokol, A.I. Svirikhin, V.A. Sbitnev, M.S. Tezekbaeva	
3. **Chemical properties of superheavy elements**	**S.N. Dmitriev**	Data taking
FLNR	N.V. Aksenov, Yu.V. Albin, A.Yu. Bodrov, G.A. Bozhikov, N.S. Gustova, V.Ya. Lebedev, K.V. Lebedev, A.Sh. Madumarov, E.V. Melnik, A.V. Rykhlyuk, A.V. Sabelnikov, G.Ya. Starodub, G.K. Vostokin, M.G. Voronyuk, I. Zvara	
4. **Experiments at the magnetic analyzer of superheavy atoms MASHA**	**A.M. Rodin**	Data taking
FLNR	E.V. Chernusheva, A.V. Guljaev, A.V. Guljaeva, D. Kamas, A.B. Komarov, L. Krupa, A.S. Novoselov, A.Opihal, A.V. Podshibyakin, V.S. Salamatin, S.V. Stepantsov, V.Yu. Vedeneev, S.A. Yukhimchuk	
5. **Study of the processes of fusion-fission, quasi-fission and multi-nucleon transfer reactions. CORSET-DEMON, CORSAR, and MiniFOBOS set-ups**	**M.G. Itkis**	Data taking
FLNR	A.A. Alexandrov, I.A. Alexandrova, I.N. Dyatlov, O.V. Falomkina, Z.I. Gorya'nova, Yu.M. Itkis, D.V. Kamanin, V.V. Kirokasian, E.M. Kozulin, N.I. Kozulina, G.N. Knyazheva, E.A. Kuznetsova, K.V. Novikov, A. Pan, I,V, Pchelintsev, Yu.V. Pyatkov, E.O. Savelieva, Yu.B. Semenov, A.N. Solodov, A.O. Strekalovsky, O.V. Strekalovskiy, I.V. Vorob'ev, A.O. Zhukova, V.E. Zhuchko	
LIT	P.V. Goncharov, G.A. Ososkov, A.V. Uzhinsky, V.B. Zlokazov	

6. **Study of the structure of exotic nuclei near and beyond the drip-lines at the ACCULINNA-1, ACCULINNA-2 and COMBAS fragment separators** — **A.S. Fomichev** — Data taking

FLNR	A.G. Artukh, E. Batchuluun, S.G. Belogurov, A.A. Bezbakh, N. Carjan, V. Chudoba, M.S. Golovkov, L.V. Grigorenko, A.V. Gorshkov, E.M. Gazeeva, V.A. Gorshkov, G. Kaminski, S.A. Krupko, S.A. Klygin, G.A. Kononenko, D.A. Kislukha, K.A. May, B. Mauyey, I.A. Muzalevskiy, E.Yu. Nikolskii, Yu.L. Parfenova, S.A. Rimzhanova, Yu.M. Sereda, S.I. Sidorchuk, R.S. Slepnev, P.G. Sharov, A. Serikov, G.M. Ter-Akopian, R. Wolski, A.N. Vorontsov, B. Zalewski
BLTP	S.N. Ershov, N.B. Shulgina

7. **Investigation of reactions induced by stable and radioactive ion beams leading to the formation of exotic nuclei. Development of MAVR and MULTI set-ups** — **Yu.E. Penionzhkevich** — Data taking

FLNR	D.T. Aznabaev, M.P. Ivanov, S.M. Lukyanov, V.A. Maslov, K.O. Mendibaev, Z.D. Pokrovskaya, R.V. Revenko, N.K. Skobelev, Yu.G. Sobolev, I. Sivacek, V.I. Smirnov, D.A. Testov

8. **Theoretical studies of nuclear reaction mechanisms** — **A.V. Karpov**

FLNR	E.A. Cherepanov, A.S. Denikin, Yu.A. Muzichka, M.A. Naumenko, V.A. Rachkov, V.V. Samarin, V.V. Saiko

9. **Development and update of the network knowledge base on nuclear physics** — **A.V. Karpov**, **A.S. Denikin** — Data taking

FLNR	M.A. Naumenko, V.A. Rachkov, V.V. Samarin, V.V. Saiko
LIT	E.I. Alexandov, V.V. Korenkov, P.V. Zrelov

10. **Laser spectroscopy of isotopes** — **S.G. Zemlyanoy** — Data taking

FLNR	K.A. Avvakumov, G.N. Myshinskiy, V.I. Zhemenik, B. Zuzaan

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
	Beijing	PKU

Czech Republic	Prague	CTU
		VP
	Olomouc	UP
	Řež	NPI CAS
Egypt	Giza	CU
	Shibin El Kom	MU
Finland	Jyväskylä	UJ
France	Caen	GANIL
	Orsay	CSNSM
		IPN Orsay
	Saclay	SPhN CEA
		DAPNIA
	Strasbourg	CRN
		IPHC
Germany	Berlin	HZB
	Darmstadt	GSI
	Mainz	JGU
	Tübingen	Univ.
India	New Delhi	IUAC
	Kolkata	VECC
	Manipal	MU
Italy	Catania	INFN LNS
	Legnaro	INFN LNL
	Messina	UniMe
	Naples	Unina
Japan	Wako	RIKEN
	Tokai	JAEA
Kazakhstan	Almaty	INP
		IETP KazNU
	Astana	ENU
Mongolia	Ulaanbaatar	NRC NUM
Poland	Warsaw	UW
		IEP WU
	Krakow	NINP PAS
	Poznan	AMU
Romania	Bucharest	IFIN-HH
Russia	Moscow	IPCE RAS
		MSU
		MUCTR
		NNRU "MEPhI"
		NRC KI
		SINP MSU
	Moscow, Troitsk	INR RAS
	Moscow, Zelenograd	RIMST
	Dimitrovgrad	SSC RIAR

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

03–2–1100–2010/2021	Priority: 1

Status: Extended

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, Russia, Romania, Slovakia, Ukraine, USA, United Kingdom, Uzbekistan.

Issues addressed and main goals of research:

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 major results in the current year:

- Data taking in the $2\beta0\nu$-decay measurements of ^{106}Cd, ^{82}Se, ^{150}Nd, ^{76}Ge with the SuperNEMO and GERDA spectrometers.
- Processing of experimental data and determination of $T_{1/2}(2\beta2\nu)$ for ^{48}Ca, ^{96}Zr,^{130}Te, ^{116}Cd, ^{150}Nd, ^{82}Se and ^{76}Ge.
- Data taking with HPGe-based low-background spectrometer at the Kalinin Nuclear Power Plant. Search for a signal of coherent neutrino scattering on the Germanium nuclei. Search for neutrino magnetic moment on the level sensitivity of $\sim 10^{-12}\mu_B$.
- Continuation of data taking in the EDELWEISS experiment with new detectors operating with an energy threshold of 0.3 keV suitable for the extra-low mass WIMP region. Analysis of previously accumulated data.
- Research and development of the semiconductor-based detecting systems for the GERDA and MAJORANA experiments. Continuation of the data taking in both experiments.
- Data taking and development of the 3-rd and 4-th clusters of the Baikal-GVD telescope (Baikal project).
- Investigation of KLL and KMM Auger electrons in ^{67}Ga and ^{152,154,155}Eu decays.
- Development and testing of new low-threshold ($\sim$ 200 eV) HPGe detectors for searching the coherent neutrino scattering, as well as plastic scintillator detectors for their active shielding.
- Testing of certain systems of the DANSS neutrino detector. Data taking in order to search for the sterile neutrino. Data analysis and publication. Development of the industrial reactor monitoring with the DANSS spectrometer.

List of projects:

	Project	Leader	Priority (period of realization)
1.	SuperNEMO	O.I. Kochetov	1 (2013 – 2021)

2. GEMMA–II	V.B. Brudanin	1	(2010 – 2021)
3. EDELWEISS–II	E.A. Yakushev	1	(2010 – 2021)
4. G&M (GERDA)	K.N. Gusev	1	(2010 – 2021)
5. DANSS	V.B. Brudanin V.G. Egorov	1	(2011 – 2021)
6. BAIKAL	I.A. Belolaptikov V.B. Brudanin	1	(2009 – 2023)

List of activities:

Activity or experiment **Laboratory or other Division of JINR** **Responsible person**	**Leaders** **Main researchers**	**Status**
1. **SuperNEMO Project**	**O.I. Kochetov**	R&D Data taking
DLNP	V.A. Bednyakov, D. Filosofov, I.I. Kamnev, D. Karaivanov, Yu. Shitov V.V. Timkin, V.I. Tretyak, O.V. Vagina	
BLTP	F. Simkovic	
2. **TGV Project**	**N.I. Rukhadze** **I. Shtekl**	Data taking
DLNP	V.G. Sandukovsky, S.L. Katulina	
BLTP	F. Simkovic	
3. **G&M (GERDA–MAJORANA Project)**	**K.N. Gusev**	Preparation Data taking
DLNP	V.B. Brudanin, A.A. Klimenko, A.V. Lubashevsky, S.L. Katulina, N.S Rumyantseva, V.G. Sandukovsky, E.A. Shevchik, S.I. Vasilyev, I.V. Zhitnikov, D.R. Zinatulina	
BLTP	F. Simkovic	
4. **GEMMA–III Project**	**V.B. Brudanin** **A.V. Lybashevsky** **E.A. Yakushev**	Modernization Data taking
DLNP	V.V. Belov, V.G. Egorov, M.V. Fomina, D.V. Medvedev, D.V. Ponomarev, V.G. Sandukovsky, M.V. Shirchenko, S.V. Rozov, I.E. Rozova, I.V. Zhitnikov, D.R. Zinatulina	
5. **EDELWEISS–LT Project**	**E.A. Yakushev** **S.V. Rozov**	Modernization Data taking
DLNP	V.B. Brudanin, D.V. Filosofov, Z. Kalaninova, A.V. Lubashevsky, N.A. Mirzaev, L.L. Perevoshchikov, D.V. Ponomarev, F.V. Rakhimov, I.E. Rozova, K.V. Shakhov	
6. **BAIKAL Project**	**I.A. Belolaptikov** **V.B. Brudanin**	Preparation Data taking
DLNP	R. Dvornicky, A.A. Doroshenko, K.V. Golubkov, V.G. Egorov, K.V. Konishev, M.M. Kolbin, A.V. Korobchenko,	

A.A. Klimenko, V.P. Lomov, M.B. Milenin, V. Nazari, D.P. Petukhov, E.N. Pliskovski, A.I. Panfilov, I.E. Rozova, V.D. Rushay, A.V. Salamatin, G.B. Safronov, M.V. Shirchenko

7. **DANSS Project**	**V.B. Brudanin** **V.G. Egorov**	Preparation
DLNP	V.V. Belov, M.V. Fomina, A.S. Kuznetsov, I.E. Rozova, N.S. Rumyantseva, M.V. Shirchenko, E.A. Shevchik, D.R. Zinatulina, I.V. Zhitnikov	

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 CAS
Finland	Jyväskylä	UJ
France	Orsay	CSNSM
		LAL
	Bordeaux	CENBG
	Caen	UNICAEN
Germany	Heidelberg	MPIK
	Mainz	JGU
	Munich	TUM
Kazakhstan	Almaty	INP
Mongolia	Ulaanbaatar	NRC NUM
		IPT MAS
Poland	Krakow	NINP PAS
		AGH-UST
	Lublin	UMCS
	Otwock-Swierk	NCBJ
Romania	Bucharest	IFIN - HH
		UB
Russia	Moscow, Troitsk	INR RAS
		HPPI RAS
	Gatchina	NRC KI PNPI
	Voronezh	VSU
	Moscow	NRC KI
		SC "VNIINM"
		NNRU "MEPhI"
		ITEP
		SINP MSU

		INTRA
		RADON
	Dubna	Dubna State Univ.
	Sarov	VNIIEF
	St. Petersburg	SPbSU
		Ioffe Institute
	Tomsk	NPI TPU
		IHCE SB RAS
Slovakia	Bratislava	CU
		IEE SAS
Ukraine	Kiev	KINR NASU
	Kharkov	ISC NASU
United Kingdom	London	UCL
	Manchester	UoM
USA	Irvine, CA	UCI
	Austin, TX	UT
Uzbekistan	Tashkent	INP AS RUz
		IAP NUU
	Samarkand	SSU

03–2–1102–2010/2019	Priority: 1
	Status: Extended

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

Leaders: G.A. Karamysheva
S.L. Yakovenko

Participating countries and international organizations:

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

Issues addressed and main goals of research:

Modernization of the JINR Phasotron and beam channels. Design of the cyclotrons for medical purposes. Development and production of the superconducting cyclotron SC202 for proton therapy in collaboration with IPP Hefei, China.

Expected major results in the current year:

- Development of physical and technical methods and codes for the design of new cyclotron-type accelerators.
- Conducting measurements of the magnetic field in the manufactured magnet of the SC202 cyclotron and analyzing the results. Formation of the magnetic field.
- Participation in commissioning of the SC202 cyclotron in IPP (Hefei, China).
- Participation in production of a rotary magnet MC1 for the AIC-144 cyclotron transport line.

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **Modernization of the Phasotron and beam channels**	**S.L. Yakovenko** **N.G. Shakun**	Realization
DLNP	S.A. Gustov, G.A Kononenko, I.V. Mirokhin, Yu.A. Polyakov, V.M. Romanov, V.I. Smirnov, S.B. Vorozhtsov, V.A. Utkin	
2. **Design of the cyclotrons for medical purpose**	**G.A. Karamysheva**	Technical proposal
DLNP	R.V. Galkin, S.V. Gursky, A.F. Chesnov, S.N. Dolya, O.V. Karamyshev, G.G. Kazakova, I.N. Kiyan, O.E. Lepkina, O.V. Lomakina, D.S. Petrov, V.M. Romanov, E.V. Samsonov, V.G Sazonov, I.M. Sedyh, S.G. Shirkov, S.B. Vorozhtsov, N.L. Zaplatin	
LIT	I.V. Amirkhanov	
3. **Development and production of the superconducting cyclotron SC202 for proton therapy for IPP CAS, Hefei, China**	**G.D. Shirkov**	R&D

DLNP	K.S. Bunyatov, A.F. Chesnov, R.V. Galkin, S.V. Gursky, O.V. Karamyshev, I.N. Kiyan, O.E. Lepkina, O.V. Lomakina, V.A. Malinin, V.M. Romanov, D.V. Popov, S.G. Shirkov	
VBLHEP	A.S. Kostromin	
LIT	I.V. Amirhanov, T.V. Karamysheva	
FLNR	I.A. Ivanenko	

4. **Development of the physical and technical methods and codes for the design of new cyclotron-type accelerators** — **S.B. Vorozhtsov** — Realization

DLNP	V.L. Smirnov, V.M. Romanov N.L. Zaplatin

Collaboration

Country or International Organization	City	Institute or Laboratory
Belgium	Louvain-la-Neuve	IBA
Czech Republic	Řež	NPI CAS
China	Hefei	IPP CAS
Japan	Chiba	NIRS
Poland	Krakow	NINP PAS
USA	Lansing, MI	IONETIX
Uzbekistan	Tashkent	INP AS RUz

03-4-1128-2017/2019	Priority: 1

Status: Being concluded

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, Germany, Greece, Hungary, India, Japan, Kazakhstan, Macedonia, Moldova, Mongolia, Norway, Poland, Republic of Korea, Romania, Russia, Serbia, Slovakia, Slovenia, South Africa, Switzerland, Thailand, Turkey, Ukraine, USA, Uzbekistan, Vietnam.

Issues addressed and main goals of research:

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 major results in the current year:

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

- Preparation and conducting an experiment on measurement of the T-odd effects in the fission of ^{233}U on a beam of IBR-2 reactor.
- Conducting an experiment on measurement of the neutron paramagnetic resonance of the first kind in samples of titanium hydride TiH_2 in the polarized neutron energy range of 0.062-2.3 eV using the KOLKHIDA facility at the IBR-2 reactor.
- Measurement of the quaternary and search for the quinary fission using a spontaneous fission source ^{252}Cf.
- Measurement of angular and energy neutron-gamma and neutron-neutron correlations in the inelastic neutron scattering and in $(n, 2n)$ reaction in the framework of the TANGRA project.
- Conducting the measurements of the $^{35}Cl(n,p)^{35}S$ on resonance neutrons from the IREN facility.
- Measurements of (n, α) reaction with Ni-60,61 isotopes for neutron energies E_n =4.5-6.5 MeV at the accelerator EG-4.5 of the Institute of Heavy Ion Physics of Peking University.

Investigation of fundamental properties of the neutron, UCN physics:

- Preparation of a project on measurement of the neutron lifetime on a beam of the IBR-2 reactor. Performing methodical measurements.
- Search for a constraint at a level of 10^{-16} for the product of the coupling constants of the scalar and pseudoscalar axion-like interaction at distances of ~ 10 μm at the GRANIT spectrometer.

- Investigation of "small UCN heating" phenomena in the interaction of UCN with nanoparticles of different sizes to test predictions of the theoretical model.
- Manufacturing and testing of a setup to measure the UCN loss factor as a function of UCN energy at the energy range close to limit energy values.
- Preparation of the project of a new experimental setup for observation of neutron quantum tunneling.
- Conducting of measurements on neutron diffraction by surface ultrasonic waves.

Applied and methodological research:

- Manufacturing and testing of a 2D position-sensitive detector.
- Development of a 32-channel neutron multiplicity detector system based on scintillation detectors.
- Manufacturing of two sections of the neutron multiplicity detector based on SNM-14D counters.
- Measurements of thin layers using methods of Elastic Recoil Detection Analysis, Rutherford Backscattering Spectrometry and X-ray analysis for various materials at the EG-5 accelerator.
- Elemental and isotopic analysis of archaeological samples at the IREN facility using neutron activation method.
- Development of a 16-channel scintillation detector for neutron resonance capture analysis at the IREN facility.
- Development of the elemental analysis technique using the tagged neutron method and standard neutron sources with the help of HPGe detectors and NaI(Tl) and BGO scintillators.
- Carrying out of neutron activation analysis of environmental, geological, biological samples and novel materials at the IBR-2 reactor using the REGATA facility.
- Equipping with computers and modern software for the neutron activation analysis facility at INP (Almaty, Kazakhstan). Training of INP personnel on the basics of neutron activation analysis.

Development of the IREN facility

- Replacement of the 2129 Thomson klystron of the second accelerating section for the E3730A klystron Toshiba.
- Providing the neutron beam time from IREN for physical experiments,

List of projects:

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

List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. **Investigations of violations of fundamental symmetries in neutron-nucleus interactions and related data**	**Yu.N. Kopatch**	Upgrade Data taking Data analysis

	FLNP	G.S. Ahmedov, N.V. Bazjazjina, D. Berikov, S.B. Borzakov, B. Buadze, Chan Van Fuk, I.I. Chuprakov, G.V. Daniljan, E. Demir, S. Enkhbold, Fan Lyong Tuan, Yu.M. Gledenov, D.N. Grozdanov, N.A. Gundorin, A.P. Kobzev, M. Kulik, V.L. Kuznetsov, Zh.V. Mezentseva, Nguen Ngok An, Nguyen Thi Bao Mi, V.V. Novitsky, I.A. Oprea, K.D. Oprea, Yu.N. Pokotilovskij, A.B. Popov, S.F. Samadov, P.V. Sedyshev, M.V. Sedysheva, O.V. Sidorova, V.R. Skoj, A.M. Suhovoj, S.A. Telezhnikov, T.Yu. Tretyakova, M. Tsulaja, Vu Dyk Kong, Sh.S. Zeynalov, 20 engineers, 3 workers
2. **Investigation of the fundamental properties of the neutron, UCN physics**	**E.V. Lychagin**	Upgrade Data taking Data analysis
	FLNP	G.G. Bunatyan, T.L. Enik, A.I. Frank,W.I. Furman, S.V. Gorunov, V.K. Ignatovich, G.V. Kulin, L.V. Mitsyna, A.Yu. Muzychka, A. Nesipbai, Yu.N. Pokotilovskij, N.Yu. Rebrova, A.V. Strelkov, E.I. Sharapov, K.N. Zhernenkov, 3 engineer, 2 workers
3. **Applied research**	**P.V. Sedyshev**	Upgrade Data taking Data analysis
	FLNP	G.S. Ahmedov, Yu.V. Alekseenok, N.V. Bazjazjina, S.B. Borzakov, D. Berikov, G.G. Bunatyan, B. Buadze, Chan Van Fuk, I. Chuprakov, O.A. Culikov, O. Chiligava, G.V. Daniljan, O.G. Duliu, T.L. Enik, S. Enkhbold, M.V. Frontasyeva, A.I. Frank, W.I.Furman, L. Gaidoshikova, V.M.B. Ged, Yu.M. Gledenov, N.A. Gundorin, S.V. Goryunov, D.N. Grozdanov, V.K. Ignatovich, G.Y. Khristozova, A.P. Kobzev, M. Kulik, G.V. Kulin, A. Madadzade, D. Mahajdik, Zh.V. Mezentseva, L.V. Mitsyna, A.Yu. Muzychka, P.S. Nekhoroshkov, A. Nesipbai, Nguyen Thi Bao Mi, V.V. Novitsky, I.A. Oprea, K.D. Oprea, S.S. Pavlov, Yu.N. Pokotilovskij, A.B. Popov, I.N. Ruskov, S.F. Samadov, M.V. Sedysheva, O.V. Sidorova, A.V. Strelkov, E.I. Sharapov, V.R. Skoj, A.M. Suhovoj, V.N. Shvetsov, S.A. Telezhnikov, M. Tsulaja, A.S. Vasilev, K.N. Vergel, E. Vieru, Vu Dyk Kong, P. Yanchik, I.I. Zinikovskaja, Sh.S. Zeynalov, K.N. Zhernenkov, 31 engineers, 9 workers
4. **Development of the IREN facility**	**V.N. Shvetsov**	Upgrade
	FLNP	V.G. Pjataev, V.V. Kobets, V.G. Shabratov, 16 engineers, 1 worker
	VBLHEP A.P. Sumbaev	V.F. Minashkin, V.N. Zamrij, 5 engineers
	DLNP	I.N. Meshkov

5. **Project TANGRA** **Yu.N. Kopatch**

Upgrade
Data taking
Data analysis

FLNP	S.B. Borzakov, P.A. Dubasov, N.A. Gundorin, D.N. Grozdanov, I.A. Oprea, K.D. Oprea, P.V. Sedyshev, V.R. Skoi, V.N. Shvetsov, T.Yu. Tretyakova, A.O. Zontikov
VBLHEP	U.Yu. Aleksakhin, S.V. Khabarov, V.L. Rapackii, Yu.N. Rogov, R.A. Salmin, M.G. Sapozhnikov, V.M. Slepnev, N.I. Zamjatin, E.V. Zubarev
DLNP	V.M. Bystritskii, A.V. Krasnoperov, A.B. Sadovskii, A.V. Salamatin
LRB	A.R. Krylov, G.N. Timoshenko

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Albania	Tirana	UT
Armenia	Yerevan	CENS NAS RA
Australia	Melbourne	Univ.
Austria	Vienna	IAEA
	Innsbruck	Univ.
Azerbaijan	Baku	BSU
		IGG ANAS
	Ganja	ASAU
		ATU
Belarus	Minsk	INP BSU
		SPMRC NASB
Belgium	Geel	IRMM
Bulgaria	Sofia	INRNE BAS
	Plovdiv	PU
		UFT
CERN	Geneva	CERN
China	Beijing	IHEP CAS
Croatia	Zagreb	Oikon IAE
		RBI
Czech Republic	Prague	CEI
		CTU
		IEAP CTU
	Ostrava	VŠB-TUO
Egypt	Cairo	EAEA
	Alexandria	Univ.
	Shibin El Kom	MU
Finland	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.
Greece	Thessaloniki	AUTH
Hungary	Budapest	RKK OU
India	Varanasi	BHU
Japan	Kyoto	KSU
	Tsukuba	KEK
Kazakhstan	Almaty	INP
	Astana	ENU
	Ust-Kamenogorsk	TRCE
Macedonia	Skopje	UKiM
Moldova	Chişinău	IMB ASM
		IC ASM
Mongolia	Ulaanbaatar	CGL
		NRC NUM
Norway	Trondheim	NTNU
Poland	Krakow	NINP PAS
	Gdansk	GUT
	Lodz	UL
	Lublin	UMCS
	Opole	UO
	Otwock-Swierk	NCBJ
	Poznan	AMU
	Wroclaw	UW
Republic of Korea	Seoul	Dawonsys
	Daejeon	KAERI
		NFRI
	Pohang	PAL
Romania	Bucharest	IFIN-HH
		INCDIE ICPE-CA
		ISS
		UB
	Baia Mare	TUCN-NUCBM
	Constanţa	NIMRD
		UOC
	Galaţi	UG

	Iaşi	UAIC
	Oradea	UO
	Piteşti	ICN
	Târgovişte	UVT
Russia	Moscow	Atomenergomach
		GIN RAS
		GPI RAS
		IKI RAS
		IPCE RAS
		ITEP
		LMPR MONIKI
		MSU
		NRC KI
		SINP MSU
		VNIIA
	Moscow, Troitsk	INR RAS
	Borok	IBIW RAS
	Dubna	Diamant
		Dubna State Univ.
	Gatchina	NRC KI PNPI
	Irkutsk	LI SB RAS
	Ivanovo	ISUCT
	Izhevsk	UdSU
	Nizhny Novgorod	IPM RAS
	Obninsk	IPPE
	Ryazan	RSU
	Snezhinsk	VNIITF
	St. Petersburg	Botanic Garden BIN RAS
		FIP
		Ioffe Institute
		Hermitage
		KRI
		SPSFTU
	Sevastopol	IBSS
	Tula	TSU
	Voronezh	VSU
	Yekaterinburg	UrFU
Serbia	Belgrade	IPB
		Univ.
	Novi Sad	UNS
Slovakia	Bratislava	CU
		IP SAS
		IEE SAS
		ILE SAS

Slovenia	Ljubljana	GeoSS
South Africa	Pretoria	UNISA
	Stellenbosch	SU
Switzerland	Villigen	PSI
Thailand	Hat Yai	PSU
Turkey	Çanakkale	ÇOMU
Ukraine	Kiev	KINR NASU
		NUK
	Kharkov	ISMA NASU
		NSC KIPT
	Donetsk	DonIPE
	Sumy	IAP NASU
	Uzhgorod	IEP NASU
USA	Athens, AL	ASU
	Durham, NC	Duke
	Gettysburg, PA	GC
	Kingston, RI	URI
	Los Alamos, NM	LANL
	Oak Ridge, TN	ORNL
	Tuscaloosa, AA	UA
Uzbekistan	Tashkent	INP AS RUz
Vietnam	Hanoi	IOP VAST
		VNU

Condensed Matter Physics, Radiation and Radiobiological Research (04)

04-4-1121-2015/2020	Priority: 1

Status: In-progress

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.

Issues addressed and main goals of research:

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 major results in the current year:

Realization of 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 nanostructured magnetic oxides.
- Determination of the structural changes during the charging/discharging processes and its relationship with electrode microstructure in compact power sources.
- Operando analysis of the processes of deposition of electrically active ions from liquid electrolytes on electrochemical interfaces.
- Revealing of proximity effects in magnetic layered nanostructures and analysis of magnetic properties in time-independent and constant magnetic fields.
- Determination of the structural stability of colloid systems, including medical and biological solvents, in bulk and at interfaces.
- Determination of structural characteristics of nanosystems based on compositional C- and Si-containing materials, including fullerenes, nanodiamonds and their bioactive derivatives.
- 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.
- Clarification of molecular mechanisms of protein interactions, dimerization and functional characteristics of supramolecular structures and complexes.

- Determination of structural characteristics of lipid nanosystems in order to study the transport of pharmacological drugs through the skin.
- Analysis of metamorphic, geodynamic and evolution processes in the lithosphere using data on the texture of deep and near-surface earth rocks. Exploration of seismic anisotropy origin.
- Determination of residual stresses and microdeformations in industrial products and modern constructional materials, induced by various technological processes (metallic and thermic treatment, welding, etc.).
- Determination of the relationship between the microstructure and thermomechanical properties of prospective functional and constructional materials (steels, alloys, composites, metalloceramics, etc.).
- Elaboration of 3D models of internal arrangement of cultural and natural heritage objects, industrial materials and products using neutron tomography method.
- Clarification of radiation damage mechanisms of solid-state materials, obtaining of long-life operating data on radiation resistance of materials.

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

- Improvement of technical parameters and extension of experimental capabilities of the new DN-6 diffractometer for studies of microsamples (replacement of the tail part of the neutron guide, development of high-pressure cells and infrastructure).
- Improvement of technical parameters and extension of experimental capabilities of the multifunctional reflectometer GRAINS (installation of polarizing system, development and fabrication of electrochemical and liquid-containing cells for experiments).
- Modernization of available IBR-2 fasiliry spectrometers (HRFD, RTD, DN-12, 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).
- Creation of test configuration of small-angle spin-echo spectrometer on IBR-2 reactor beamline 9.
- Development of the concept of modernization or reconstruction of the inelastic neutron scattering spectrometer NERA and start of its realization.
- Improvement of technical parameters of the neutron radiography and tomography spectrometer on IBR-2 beamline 14 (spatial resolution, radiation stability of detector system).
- Adaptation of the correlation spectrometer FSS on IBR-2 reactor beamline 13 and improvement of its technical parameters. Further development of the correlation RTOF-method.
- Development and fabrication of elements of basic configuration of the small-angle scattering and imaging spectrometer (neutron beam forming system, biological shielding).
- Development and testing of neutron scattering methods for condensed matter research including spin-echo, neutron standing waves, isotope neutron reflectometry, neutron magnetic resonance, radiography, tomography, etc.
- Development of neutron scattering methods for in-operando monitoring and studies of electrochemical materials and interfaces.

List of projects:

Project	Leader	Priority (period of realization)
1. ELCHEM-NS	M.V. Avdeev Deputies: V.I. Petrenko I.A. Bobrikov	1 (2018 – 2020)

List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. **Study of structure and properties of novel functional materials**	**A.M. Balagurov** **D.P. Kozlenko**	Data taking
FLNP	B. Argymbek, E.B. Askerov, A.I. Beskrovnyi, I.A. Bobrikov, M.L. Craus, E.V. Ermakova, N.O. Golosova, S.E. Kichanov, E.V. Lukin, G.M. Mironova, D.T. Neov, A. Pawlukojc, E.P. Popov, A.V. Rutkauskas, B.N. Savenko, N.Yu. Samoylova, S.T. To, V.A. Turchenko	
LIT	V.B. Zlokazov	
2. **Study of structure and properties of materials under extreme conditions**	**D.P. Kozlenko**	Data taking
FLNP	N.M. Belozerova, E.V. Lukin, S.H. Jabarov. S.E. Kichanov, A.V. Rutkauskas, B.N. Savenko	
3. **Study of fundamental regularities of real time processes in condensed matter**	**A.M. Balagurov**	Data taking
FLNP	A.I. Beskrovnyi, I.A. Bobrikov, O.Yu. Ivanshina, G.M. Mironova, D. Neov, E.P. Popov, N.Yu. Samoylova, V.G. Simkin	
4. **Computer modeling of physical and chemical properties of novel crystalline and nanostructured materials**	**A. Pawlukojc**	Data taking
FLNP	K.S. Druzbicki, K.M. Luczynska	
5. **Study of magnetic properties of layered nanostructures**	**Yu.V. Nikitenko**	Data taking
FLNP	S.V. Kozhevnikov, V.D. Zhaketov	
6. **Study of structural characteristics of carbon- and silicon-based nanomaterials**	**V.L. Aksenov**	Data taking
FLNP	D.M. Chudoba, O.A. Kizima, T. Nagornaya, T.V. Tropin, A.A. Tomchuk	

7.	**Characterization of nanostructures and their application as carriers for drug delivery**	**D.M. Chudoba**	Data taking
	FLNP	M. Jaźdźewska, K.B. Ludzik-Dychto, A. Nazarova	
8.	**Investigation of molecular dynamics of functional materials**	**D.M. Chudoba**	Data taking
	FLNP	P. Bilski, K.S. Druzbicki, E.A. Goremychkin, M. Jaźdźewska, K.M. Luczynska, K.B. Ludzik-Dychto, T. Nagornaya, A. Nazarova, J. Waliszewski	
9.	**Study of dispersed systems and complex liquids in bulk and at interface boundaries**	**M.V. Avdeev**	Data taking
	FLNP	A.P. Artikulny, I.V. Gapon, M.O. Kuzmenko, K.T. Kholmurodov, A.V. Nagornyi, V.I. Petrenko, A.V. Tomchuk	
10.	**Structural characterization of polymer nanodispersed materials**	**M. Balasoiu**	Data taking
	FLNP	A.Kh. Islamov, O.I. Ivan'kov, A.I. Kuklin, A.V. Rogachev, D.V. Solovyev	
11.	**Study of supramolecular structure and functional characteristics of biological macromolecules, complexes and membrane proteins**	**A.I. Kuklin**	Data taking
	FLNP	M. Balasoiu, Yu.E. Gorshkova, A.Kh. Islamov, O.I. Ivan'kov, Yu.S. Kovalev, T.N. Murugova, A.A. Nabiev, A.V. Rogachev, D.V. Solovyev	
	LIT	D.V. Solovyev, T.V. Solovyeva	
12.	**Study of structure and properties of lipid membranes and lipid complexes**	**M.A. Kiselev**	Data taking
	LIT	E.V. Zemlyanaya, E.I. Zhabitskaya	
13.	**Study of texture and physical properties of Earth's rocks, minerals and engineering materials**	**Ch. Scheffzuek** **D.I. Nikolaev**	Data taking
	FLNP	B. Altangerel, T.I. Ivankina, T.A. Lychagina, V.V. Sikolenko, R.N.Vasin, I.Yu. Zel'	
14.	**Non-destructive control of residual stresses in industrial products and engineering materials**	**G.D. Bokuchava**	Data taking
	FLNP	A.A. Kruglov, D.M. Levin, B. Muhametuly, I.V. Papushkin, V.V. Sumin, A.V. Tamonov, Yu.V. Taran, R.N. Vasin	

15. **Neutron imaging of internal structure of industrial products, rocks, cultural and natural heritage objects** — **D.P. Kozlenko, G.D. Bokuchava** — Data taking

FLNP: S.E. Kichanov, E.V. Lukin, K. Nazarov, A.V. Rutkauskas, B.N. Savenko

16. **Study of radiation damage effects in condensed matter by X-ray spectroscopy** — **S.I. Tyutyunnikov (VBLHEP)** — Data taking

VBLHEP: V.V. Efimov, A.A. Efimova, Yu.S. Kovalev, I.A. Kryachko, A.V. Rogachev, V.N. Shalyapin, N.I. Zamyatin

17. **Development of neutron scattering methods for interdisciplinary studies of nanosystems and materials** — **V.I. Bodnarchuk, G.D. Bokuchava, D.P. Kozlenko** — Data taking

FLNP: S.V. Kozhevnikov, S.E. Kichanov, E.V.Lukin, Yu.V. Nikitenko, S.P. Yaradaikin

18. **Development of the IBR-2 fasiliry spectrometer complex** — **D.P. Kozlenko, A.M. Balagurov** — Realization

FLNP: M.V. Avdeev, A.I. Beskrovnyi, I.A. Bobrikov, G.D. Bokuchava, V.I. Bodnarchuk, D.M. Chudoba, A.S. Doroshkevich, A.I. Kuklin, V.M. Morozov, D. Neov, Yu.V. Nikitenko, A.V. Petrenko, E.P. Popov, B.N. Savenko, V.G. Simkin, V.I. Sukhanov, 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	ASCI Ltd
		IE BAS
		IEES BAS
		IMS BAS
		INRNE BAS
		ISSP BAS
Czech Republic	Prague	CTU
		IG CAS
		IMC CAS
		IP CAS

	Ostrava	VŠB-TUO
	Řež	NPI CAS
Egypt	Cairo	EAEA
	Giza	CU
France	Grenoble	IBS
	Saclay	LLB
Germany	Berlin	HZB
		BAM
	Bayreuth	Univ.
	Bochum	RUB
	Darmstadt	TU Darmstadt
	Dortmund	TU Dortmund
	Dresden	TU Dresden
		IKTS
	Göttingen	Univ.
	Geesthacht	GKSS
	Freiberg	TUBAF
		IMF TUBAF
	Halle	MLU
	Hamburg	DESY
	Jülich	FZJ
	Karlsruhe	KIT
	Kiel	CAU
		IFM-GEOMAR
	Potsdam	GFZ
	Rostock	Univ.
	Stuttgart	MPI-FKF
Hungary	Budapest	Wigner RCP
	Szeged	US
India	Gurgaon	AMITY
	Patna	NIT Patna
Italy	Trento	UniTn
Japan	Minato	Keio Univ.
	Nagano	Shinshu Univ.
Kazakhstan	Almaty	INP
	Rudny	RII
Latvia	Riga	ISSP UL
		IPE
Moldova	Chişinău	IMB ASM
		IC ASM
Mongolia	Ulaanbaatar	IPT MAS
		MUST
Norway	Trondheim	NGU
Poland	Warsaw	INCT
	Bialystok	UwB

	Krakow	JU
		AGH-UST
		NINP PAS
	Lodz	UL
	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
	Cluj-Napoca	INCDTIM
		RA BC-N
		UBB
		UTC-N
	Constanţa	UOC
	Craiova	UC
	Iaşi	USAMV
		NIRDTP
		TUIASI
		UAI
		UAIC
	Piteşti	ICN
		UPIT
	Timişoara	ICT
		LMF CCTFA
		RA TB
		UPT
		UVT
	Târgovişte	UVT
	Tulcea	DDNI
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
	PIN RAS
	SINP MSU
	SC "VNIINM"
Moscow, Troitsk	HPPI RAS
	ISAN
	INR RAS
Belgorod	BelSU
Chernogolovka	ISSP RAS
Dolgoprudny	MIPT
Dubna	Dubna State Univ.
Gatchina	NRC KI PNPI
Kaliningrad	IKBFU
Kazan	KNRTU
	KFU
Krasnoyarsk	SibFU
	KIP SB RAS
Nizhny Novgorod	UNN
	IPM RAS
Perm	ICMM UrB RAS
	ITCh UrB RAS
Petrozavodsk	IG KRS RAS
Podolsk	GIDROPRESS
Rostov-on-Don	RIP SFU
St. Petersburg	Ioffe Institute
	SPbSU
	IMC RAS
Sterlitamak	SSPA

	Tomsk	NPI TPU
	Tula	TSU
	Yekaterinburg	IMP UB RAS
		UrFU
Serbia	Belgrade	INS "VINČA"
	Novi Sad	UNS
Slovakia	Bratislava	CU
	Košice	IEP SAS
South Africa	Pretoria	Necsa
Spain	Madrid	CENIM-CSIC
Switzerland	Villigen	PSI
	Zurich	ETH
Tajikistan	Dushanbe	IChem ASRT
Taiwan	Hsinchu	NSRRC
Ukraine	Kiev	DonIPE NASU
		IPMS NASU
		NUK
		ISC NASU
	Donetsk	DonNU
		DonIPE
	Kharkov	IERT NASU
		NSC KIPT
United Kingdom	Didcot	RAL
Uzbekistan	Tashkent	INP AS RUz
Vietnam	Hanoi	IOP VAST
	Da Nang	DTU

04-4-1105-2011/2019	Priority: 1

Status: Being concluded

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, Japan, Mongolia, Poland, Romania, Russia, United Kingdom, USA.

Issues addressed and main goals of research:

The theme main task of the theme 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 major results in the current year:

- Maintenance of the IBR-2 reactor operation for physical investigations.
- Assembling of a reserve movable reflector MR-3R at FLPN test bench.
- Putting into test operation of the CM-201 cryogenic moderator equipment at a working place.
- 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 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**	**A.V. Dolgikh** **A.V. Vinogradov**	Realization
	FLNP	M.V. Andrianov, A.A. Belyakov, Yu.N. Pepelyshev, S.V. Rudenko, S.A. Tsarenkov, V.A. Trepalin, 30 engineers, 50 workers	
2.	**Maintenance of program of physical investigations**	**A.V. Vinogradov** **A.V. Dolgikh**	Realization
	FLNP	A.A. Belyakov, Yu.N. Pepelyshev, S.V. Rudenko, V.A. Trepalin, 30 engineers, 50 workers	

3. **Installation and adjustment of equipment and pipelines of CM-201 cryogenic moderator at test bench. Test operation of equipment of CM-202 and CM-201 cryogenic moderators using a new cryogenic facility by "Linde"**
   A.A. Belyakov
   K.A. Mukhin
   Realization

   FLNP — S.A. Kulikov, E.P. Shabalin, 15 engineers, 15 workers

4. **Assembling of reserve movable reflector MR-3R**
   A.V. Vinogradov
   A.V. Dolgikh
   Realization

   FLNP — A.A. Belyakov, 5 engineers, 5 workers

5. **Step-by-step replacement and upgrade of basic technological and electrical equipment**
   A.V. Vinogradov
   A.V. Dolgikh
   Realization

   FLNP — A.A. Belyakov, A.V. Trepalin, 30 engineers, 50 workers

Collaboration

Country or International Organization	City	Institute or Laboratory
Argentina	Buenos Aires	CNEA
Azerbaijan	Baku	IRP ANAS
		NNRC
Belarus	Minsk	JIPNR-Sosny NASB
Japan	Osaka	ISIR
	Sapporo	Hokkaido Univ.
Mongolia	Ulaanbaatar	IPT MAS
Poland	Krakow	AGH-UST
Romania	Bucharest	IFIN-HH
Russia	Moscow	NIKIET
		Geliymash
		INEUM
		SYSTEMATOM
		SSDI
		ENES
United Kingdom	Didcot	RAL
USA	Indianapolis, IN	IUPUI

04-4-1122-2015/2020	Priority: 1
	Status: In-progress

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

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

Participating countries and international organizations:

Argentine, Belarus, Bulgaria, Czech Republic, Germany, Hungary, Republic of Korea, Romania, Russia, South Africa, Sweden, Switzerland, Ukraine, United Kingdom, Uzbekistan.

Issues addressed and main goals of research:

Development and construction of a control system of the cryogenic moderator CM-201 for IBR-2 reactor beams N 1, 4, 5, 6, 9.
Design of equipment, electronics and software for the complex of IBR-2 facility 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 major results in the current year:

- Putting of a control system of CM-201 moderator for beamlines N 1, 4, 6-9 into trial operation; testing and adjustment of the system during reactor operation at a power of 2 MW. Carrying out of test loading of CM-201 moderator chamber with frozen mesitylene pellets during reactor power operation. Tests of an optical sensor used to control the movement of pellets and count them during their transportation to the moderator chamber at a special test stand of CM-201. Current modernization and maintenance of CM-202. Determination of release of radiolytic hydrogen in CM-202 moderator chamber using chromatographic equipment during reactor power operation.
- Investigation of radiation resistance of materials at the radiation research facility. Development of a system for moving highly active samples using a robotic manipulator.
- Optimization of parameters of spectrometer components by Monte Carlo simulation.
- Assembling of a horizontal/vertical cryostat with a superconducting magnet and variable temperature range of 4-300 K; start-up of the cryostat in the cooling mode of the magnet in a heat-exchange gas; carrying out of preparatory work for the installation of the cryostat at the DN-12 diffractometer. Development of continuous-flow cryostats based on closed-cycle cryocoolers. Start-up and study of a ^3He-^4He mini-liquefier. Development and modernization of cryostats, cryogenic and vacuum equipment of IBR-2 facility spectrometers.
- Carrying out of work within the project to develop and construct a wide-aperture backscattering detector for the HRFD diffractometer: purchase of equipment and consumables; manufacturing of a supporting frame, components of detector sections, and tool kit for mounting detector components; development of a prototype of data acquisition and accumulation electronics. Testing and commissioning of "ASTRA-M"detector on the Fourier diffractometer FSD. Completion of development and study of scintillation hodoscope.
- Replacement of counter modules of the detector system of the NERA-PR spectrometer. Manufacture, testing and commissioning of 2D PSD on the HRFD diffractometer. Purchase of components (tubes and electronics for signal acquisition and registration), assembling and measurement of characteristics of 1D PSD based on tubes with a resistive wire. Study of the possibility of applying additive technologies (3D printing) for manufacturing components of neutron detectors. Design and manufacturing of a new winding machine. Development of a prototype of a solid-converter-based neutron detector.

- Investigation and development of a prototype of analog electronics for processing signals from one module of a wide-aperture scintillation detector under the BSD project and completion of the development of an MPD32 USB 3.0 data acquisition system for this detector. Development of event selection algorithms for scintillation detectors and their debugging at a test stand with a new MPD32 data acquisition system. Adaptation of MPD32-USB3.0 data acquisition system for other types of detectors.
- Modernization of control systems of actuators of HRFD and FSD spectrometers. Installation of diaphragms for collimation of neutron beams in the spectrometers. Installation, adjustment and putting into trial operation of CC-3U chopper controllers as a part of a control system for choppers on GRAINS and REFLEX spectrometers. Development of control systems of two-disk choppers for IBR-2 reactor beamline 10.
- Improvement of Sonix+ complex, development of software modules for new devices and new DAQ-controllers. Adaptation of the Journal program for working with experimental data in the central FLNP data storage. Provision of access to the data storage for users working on REMUR, REFLEX and GRAINS reflectometers. Preparation for a changeover to 100-Gb/s standard in the FLNP network (gradual replacement of routers, cables, transceivers, etc.).

List of projects:

	Project	Leader	Priority (period of realization)
1.	Development of PTH sample environment system for DN-12 diffractometer at the IBR-2 facility	A.N. Chernikov	1 (2015 – 2020)
2.	BSD	V.V. Kruglov	1 (2018 – 2020)

List of activities:

	Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1.	**Development and putting into operation of control system of CM-201 moderator for neutron beams N 1, 4, 5, 6, 9**	**S.A. Kulikov** **E.P. Shabalin**	Realization
	FLNP	M.V. Bulavin, A.S. Kirilov, A.P. Sirotin, K.A. Mukhin, 8 engineers	
2.	**Calculations and simulation of spectrometers' elements. Development of VITESS software package**	**A.V. Belushkin** **V.I. Bodnarchuk**	Realization
	FLNP	S.A. Kulikov, S.A. Manoshin, 1 engineer	
3.	**Investigation of radiation resistance of materials and electronic components**	**M.V. Bulavin** **S.A. Kulikov**	Realization
	FLNP	E.P. Shabalin, 4 engineers	

4. **Tests of combined horizontal-vertical cryostat with superconducting magnet for DN-12 diffractometer. Development and modernization of cryostats on IBR-2 facility spectrometers.**

A.N. Chernikov
S.E. Kichanov

Realization

FLNP — N.A. Kovalenko, E.V. Lukin, 2 engineers

5. **Development of continuous flow cryostats on the basis of closed-cycle cryocoolers**

A.N. Chernikov

Realization

FLNP — N.A. Kovalenko, 2 engineers

6. **Development and implementation of gas and scintillation detector systems at IBR-2 facility spectrometers**

A.V. Churakov
V.V. Kruglov
A.A. Bogdzel

Realization

FLNP — V.A. Drozdov, V.M. Milkov, V.V. Zhuravlev, A.S. Kirilov, 10 engineer

7. **Development of data acquisition systems, control and experiment automation systems, as well as of software package Sonix+ at IBR-2 facility spectrometers**

V.I. Prikhodko
A.P. Sirotin
A.S. Kirilov

Realization

FLNP — A.A. Bogdzel, V.I. Bodnarchuk, S.M. Murashkevich, V.V. Zhuravlev, N.D. Zernin, 10 engineer

8. **Development of FLNP network infrastructure in accordance with development strategy of JINR computer network**

V.I. Prikhodko

Realization

FLNP — G.A. Sukhomlinov, A.S. Kirilov, S.A. Manoshin, 5 engineer

LIT — V.V. Korenkov, 2 engineers

Collaboration

Country or International Organization	City	Institute or Laboratory
Argentina	Bariloche	CAB CNEA
Belarus	Minsk	BSTU
Bulgaria	Sofia	INRNE BAS
Czech Republic	Řež	NPI CAS
Germany	Berlin	HZB
	Jülich	FZJ
Hungary	Budapest	Wigner RCP
Republic of Korea	Daejeon	NFRI
Romania	Bucharest	INCDIE ICPE-CA
Russia	Moscow	NNRU "MEPhI"

		NRC KI
		PC ITER RF
	Moscow, Troitsk	INR RAS
	Dubna	Dubna State Univ.
	Gatchina	NRC KI PNPI
	Yekaterinburg	IMP UB RAS
South Africa	Pretoria	Necsa
Sweden	Lund	ESS ERIC
Switzerland	Villigen	PSI
Ukraine	Lviv	LPNU
United Kingdom	Didcot	RAL
Uzbekistan	Tashkent	INR AS RUz

04–4-1133—2018/2020	Priority: 1

Status: In-progress

Modern Trends and Developments in Raman Microspectroscopy and Photoluminescence for Condensed Matter Studies

Leader: G.M. Arzumanyan
N. Kučerka

Participating countries and international organizations:

Armenia, Belarus, Bulgaria, Egypt, Germany, Latvia, Poland, Russia, Slovakia, Ukraine.

Issues addressed and main goals of research:

Modern trends in Raman-based microspectroscopy providing ultrasensitive, highly-contrast and chemically selective tools for condensed matter studies of extremely low concentrations of analyte molecules are in the focus of the present research programme. Detection and identification of a single molecule represent the ultimate sensitivity limit in chemical analysis. Tracking and counting of single molecules, characterizing their chemical structures offer far-reaching opportunities in basic and applied research. Therefore, vibrational spectroscopy, such as Raman spectroscopy, as a non-invasive, label-free technique, is a powerful and preferred tool for rareorganic/biological molecule studies. To achieve this goal, two enhanced options of Raman scattering, namely CARS (coherent antiStokes Raman spectroscopy) and SERS (surface-enhanced Raman spectroscopy) will be combined to attain such an ultrasensitive level of detectior – poorly studied and known as SECARS – surface-enhanced CARS.

The other modern component of the theme is the study of photo- and upconversion luminescence based on promising core-shell nanostructures. In recent years, core-shell nanoparticles are at the leading edge of hot research topics and offer a wide range of applications in biomedicine, optics, environmental science, materials, and so forth, due to their excellent properties such as versatility, tunability and stability. The core-shell nanomaterials containing noble metals are plasmonic nanomaterials. They can be employed for contrast imaging, several biomedical applications, etc.

Expected major results in the current year:

- Development of the wavelength scanning mode for picosecond coherent anti-Stokes Raman microspectrometry.
- Continuation of the tests of various configurations of SERS-active substrates to ensure optimal selection for the effective SECARS spectroscopy.
- Comparison of SERS and SECARS spectra and intensity maps of light scattered from organic reporter molecules.
- Synthesis of core-shell nanostructure:
  $NaYF_4$:Yb^{3+}, Er^{3+},Tm^{3+}@SiO_2 and tests on their toxicity.
- Realization of a contrast and selective imaging method on model samples by Raman and upconversion luminescence.

List of projects:

Project	Leader	Priority (period of realization)
1. NANOBIOPHOTONICS	G.M. Arzumanyan N. Kučerka Deputy: K.Z. Mamatkulov	1 (2018 – 2020)

List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1. **Development of scientific and technical requirements to upgrade the "CARS" microspectrometer for ultrasensitive SECARS modality**	**G.M. Arzumanyan**	Upgrade
FLNP	N.V. Doroshkevich, K.Z. Mamatkulov, I.A. Morkovnikov	
2. **Study of spectroscopic and plasmonic characteristics of SERS-active substrates based on silver/gold nanoparticles with different configurations**	**G.M. Arzumanyan** **N. Kučerka**	Data taking
FLNP	N.V. Doroshkevich, A.S. Marchenko, K.Z. Mamatkulov, N.V. Doroshkevich, M.Ju. Vorobjeva	
3. **Systematic experiments on SECARS microspectroscopy with picosecond laser pulses at SERS-active substrates – single molecule spectroscopy**	**G.M. Arzumanyan** **K.Z. Mamatkulov**	Realization Data taking
FLNP	N.V. Doroshkevich, I.A. Morkovnikov, K.Sh. Voskanyan, M.Ju. Vorobjeva	
4. **Development of plasmon-enhanced model of Raman scattering on the "CARS" microscope**	**G.M. Arzumanyan** **N. Kučerka**	Simulation
FLNP	K.Z. Mamatkulov, I.A. Morkovnikov	
5. **Study of spectral-structural characteristics of upconversion phosphors based on core-shell type nanostructures**	**G.M. Arzumanyan** **N. Kučerka**	Data taking
FLNP	N.V. Doroshkevich, K.Z. Mamatkulov, A.S. Marchenko, M.Ju. Vorobjeva, K.Sh. Voskanyan, M.Ju. Vorobjeva	
6. **Test-application of core-shell nanostructured phosphors in photodynamic therapy (PDT) of cancer**	**G.M. Arzumanyan** **N. Kučerka**	Realization
FLNP	N.V. Doroshkevich, A.S. Marchenko, K.Z. Mamatkulov, M.Ju. Vorobjeva, K.Sh. Voskanyan	
7. **Development of a united optical platform concept for contrast and selective imaging by nonlinear Raman microscopy and upconversion luminescence.**	**G.M. Arzumanyan**	Realization
FLNP	K.Z. Mamatkulov, A.S. Marchenko	

8. **Broadening the scope of research activities at the "CARS" microscope as a "user-friendly facility"**

G.M. Arzumanyan
N. Kučerka

Realization

FLNP

N.V. Doroshkevich, K.Z. Mamatkulov

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Inst. Biochemistry NAS RA
Belarus	Minsk	BSUIR
		SOL instruments
Bulgaria	Sofia	Inst. Microbiology BAS
Egypt	Giza	CU
Germany	Jülich	FZJ
Latvia	Riga	ISSP UL
Poland	Wroclaw	UW
	Poznan	AMU
Russia	Moscow	GPI RAS
		MSU
Slovakia	Košice	PJSU
Ukraine	Donetsk	DonNU

04-5-1131-2017/2021	Priority: 1

Status: In-progress

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, Germany, Hungary, Kazakhstan, Moldova, Mongolia, Poland, Romania, Russia, Serbia, Slovak Republic, South Africa, Spain, United Kingdom, USA, Vietnam.

Issues addressed and main goals of research:

Transition to a new level of research and development in the fields of radiation solid-state physics, applied radiochemistry, and materials science, with possible 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 developing of nanotechnology applications for ion beams. Upgrade of the FLNR facilities for the production of medical isotopes and developement of materials modification methods.

Expected major results in the current year:

- Molecular dynamic simulation of structural changes in single oxide crystals during overlapping of swift heavy-ion tracks.
- Study of high-energy heavy-ion irradiation effects on hydrogen and helium porosity in metals and alloys.
- Study of radiation defects generated in graphene under high-energy heavy-ion irradiation.
- Investigation of the distribution of silver nanoparticles on the surface and in the pores of track-etched membranes modified with polyethyleneimine and other linkers.
- Study of osmotic effects caused by low-molecular electrolytes in nanopores of cylindrical and conical geometry.
- Manufacture of composite track-etched membranes coated with thin layers of zinc oxide by planar magnetron sputtering and thorough study of their structure, phase composition, and electrical properties.
- Investigation of surface and electrical transport properties of composite track-etched membranes with a fluoropolymer hydrophobic layer obtained using magnetron and thermal vacuum deposition techniques.
- Application of nuclear methods for the analysis of rare-earth elements and radionuclides of the U and Th families in environmental samples provided by the research organizations in Mongolia, South Africa, and Bulgaria.

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**	**V.A. Skuratov** **P.Yu. Apel**	Data taking

FLNR	V.A. Altynov, I.V. Blonskaja, O.M. Ivanov, L.I. Kravets, O.V. Kristavchuk, N.S. Kirilkin, E.A. Korneeva, N.E. Lizunov,A.N. Nechaev, O.L. Orelovich, V.F. Reutov, D.V. Shchegolev, V.K. Semina, V.V. Shirkova, A.S. Sohatsky	
LIT	V.V. Trofimov	
FLNP	M.V. Frontasyeva, A.I. Kuklin	
2. **Production of ultra-pure isotopes**	**S.N. Dmitriev**	Manufacturing
FLNR	Yu.V. Albin, G.A. Bozhikov, T.P. Drobina, M.V. Gustova, G.Ya. Starodub, A.V. Sabelnikov, G.K. Vostokin	
3. **Radioanalytical studies**	**M.V. Gustova**	Data taking
FLNR	N.S. Gustova, S.P. Kaplina, A.V. Sabelnikov	
4. **Construction of accelerator complexes for radiation physics research**	**S.N. Dmitriev** **A.A. Chumbalov**	Designing Manufacturing
FLNR	S.L. Bogomolov, A.A. Chumbalov, I.V. Kalagin, I.V. Kolesov	

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Belarus	Minsk	BSU
		CPHEP INP BSU
		RIAPP BSU
		SPMRC NASB
	Gomel	GSU
		BNTU
Bulgaria	Plovdiv	PU
China	Beijing	Beijing Fert Co
		PKU
Cuba	Havana	CEADEN
Czech Republic	Prague	CU
	Brno	BUT
	Olomouc	UP
	Řež	NPI CAS
Germany	Darmstadt	GSI
	Quedlinburg	IST
		MiCryon Technik
Hungary	Budapest	GetGiro Kft
Kazakhstan	Almaty	IPT
	Astana	BA INP
		ENU

		NU
Moldova	Chişinău	IAP ASM
		MSU
Mongolia	Ulaanbaatar	CGL
		NRC NUM
Poland	Warsaw	INCT
		WUT
	Lublin	UMCS
	Torun	UMK
Russia	Moscow	IC RAS
		ISPM RAS
		GPI RAS
		LPI RAS
		MATI
		MIEM
		MSMU
		RIVS
		SINP MSU
	Chernogolovka	BInEPCP RAS
		ISSP RAS
	Dubna	Trackpore Technology
	Kaliningrad	IKBFU
	Krasnodar	KSU
	Novosibirsk	ISP SB RAS
	Obninsk	REATRACK-Filter
	St. Petersburg	Ioffe Institute
	Vladimir	Vladisart
Romania	Bucharest	CSSNT-UPB
		INFLPR
		IFIN-HH
		UPB
	Baia Mare	TUCN-NUCBM
Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	BIONT
		IEE SAS
		PF SK
South Africa	Port Elizabeth	NMMU
	Bellville	UWC
	Stellenbosch	SU
	Pretoria	UP
Spain	Valencia	UV
United Kingdom	London	Middlesex Univ.
USA	Stanford, CA	SU

	Knoxville, TN	UTK
	Oak Ridge, TN	ORNL
Vietnam	Hanoi	IOP VAST

04–9–1077–2015/2020	Priority: 1
	Status: In-progress

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, Italy, Mongolia, Poland, Romania, Russia, Slovakia, Vietnam.

Issues addressed and main goals of research:

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 molecular damage induction and repair in the DNA structure in mammalian and human cells for radiations with different linear energy transfer (LET) in vivo and in vitro.
- Obtaining comparative data on the regularities in the induction of gene and structural mutations in mammalian and lower eukaryote cells under exposure to sparsely and densely ionizing radiations with different LET.
- Research on the mechanisms of the heavy charged particle (HCP)-induced damage of the eye retina and its repair.
- Research on the character of the damage of central nervous system (CNS) cells and regularities of their death. Identification of the HCP-induced functional and morphological disorders in the CNS.
- Mathematical modeling of the effects of ionizing radiations with different LET at the molecular and cellular levels. Development and analysis of mathematical models of the molecular mechanisms of ionizing radiation-induced disorders in the CNS structure and functions.
- Calculation of shielding for new nuclear physics facilities, evaluation of the radiation environment, and development of radiation safety systems.

Expected major results in the current year:

- To continue studying regularities in the induction, formation, repair kinetics, and structure of HCP-induced clustered DNA double-strand breaks (DSBs) in human skin fibroblasts.
- To evaluate the proportion of different clustered DNA DSB repair pathways in human fibroblasts after exposure to radiations of different quality – by immunocytochemical staining of the repair proteins RAD51 (HR); Ku70 and DNA PKcs (NHEJ).
- To study the influence of DNA synthesis inhibitors on the formation and structure of clustered DNA damage.
- To study regularities in DNA DSB formation and elimination in rodent brain neurons after exposure in vivo and in vitro using a primary hippocampal culture from P0–P1 age rats.
- Using a Synergy H1m microplate reader, to evaluate the level of the reactive oxygen species and reactive nitrogen species protein kinase in mammalian SIM-A9 microglial cells exposed to gamma rays and HCP.
- To study the action of gamma rays, protons, and HCP on peripheral human blood lymphocytes using multicolor FISH.

- To continue studying regularities in the induction of gene and structural mutations in yeast cells by radiations with different LET.
- To evaluate chromosome aberration yield in mammalian cells at long times after exposure to ionizing radiations with different LET. To compare the results of a molecular and cytogenetic analysis of HPRT-mutant subclones.
- To continue studying the mechanisms behind the damage and recovery of retinal cell elements after radiation exposure. To monitor the changes in the composition of bis-retinoids in the retina and retinal pigment epithelium of the mouse eye after exposure to densely ionizing radiation.
- To perform a study of the modification of small laboratory animals' complex behavioral reactions after HCP exposure. To identify the specifics of the disorders of the brain cell structures and evaluate the possibility of reducing such disorders by different pharmacological agents after exposure.
- To continue the development of mathematical models of the induction and repair of the key types of DNA damage after HCP exposure.
- To continue the computer modeling of the formation of radiation-induced damage in membrane ion channels and synaptic contacts.
- To perform mathematical modeling of the development of radiation-induced oxidative stress in neurons.
- To model the electrical activity of hippocampal neural networks after radiation injury.
- To continue designing, testing and calibration of nuclear planetary science instruments with fast neutron generators at the LRB's test site.
- To ensure the conduction of radiobiological experiments at the U-400M cyclotron (the Laboratory of Nuclear Reactions) and the medical beam of the Phasotron (the Laboratory of Nuclear Problems).
- To prepare a requirement specification for the design of a radiobiological research beam at the Nuclotron (the Laboratory of High Energy Physics).

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 – 2020)

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, 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, R.D. Govorun, E.V. Ilyina, A.A. Ivanov, L. Jezkova, A.N. Kokoreva, E.A. Kolesnikova, N.A. Koltovaya, O.V. Komova, V.L. Korogodina, I.V. Koshlan, N.A. Koshlan, M.A. Kovalenko, R.A. Kozhina, E.A. Kruglyakova, P.V. Kutsalo, E.A. Kuzmina, B. Lkhagvaa, V.N. Lisy, K.N. Lyakhova, B. Munkhbaatar, E.A. Nasonova, M.A. Ostrovsky, M.S. Panina, A.Yu. Parkhomenko, D.V. Petrova, Yu.S. Severyukhin, N.V. Svaneva, N.L. Shmakova, E.V. Smirnova, S.I. Tiunchik, D.M. Utina, M.A. Vasilyeva, Yu.V. Vinogradova, T.H. Vu, M.G. Zadnepryanets, N.I. Zhuchkina, 4 engineers, 7 workers	
2. **Radiation research**	**G.N. Timoshenko**	Preparation Data taking R&D
LRB	V.E. Aleinikov, L.G. Beskrovnaya, M.M. Komochkov, 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, A.N. Bugay, 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
Bulgaria	Sofia	IE BAS
		NCRRP
Czech Republic	Brno	IBP CAS
	Prague	CTU
	Řež	NPI CAS
		UJV
Italy	Udine	Uniud
Mongolia	Ulaanbaatar	NUM
Poland	Szczecin	US
Romania	Bucharest	UMF
	Iaşi	IBR
		UAIC
Russia	Moscow	IBMP RAS
		ITEP
		MSU

		SF IPh
	Astrakhan	ASU
	Sochi	SRI MP
Slovakia	Bratislava	CU
Vietnam	Hanoi	INPC VAST

04–9–1112–2013/2019	Priority: 1

Status: Being concluded

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.

Issues addressed and main goals of research:

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 extremophile organisms, 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 major results in the current year:

- To continue the electron microscopy-based 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 at different temperatures.

- To study the nature of the catalysts participating in the synthesis of complex prebiotic compounds from formamide.
- To prepare an illustrated atlas on Orgueil meteorite microfossils.

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. **Studies of biofossils in meteorites and ancient terrestrial rocks**	**A.Yu. Rozanov** **E.A. Krasavin**	Data taking Realization Simulation
LRB	A.K. Rymin, 1 engineer	
2. **Research on the synthesis of complex prebiotic compounds from formamide**	**R. Saladino**	Data taking Realization Simulation
LRB	M.I. Kapralov, 1 student	
3. **Biogeochemical and biological studies of cosmic dust**	**L.M. Gindilis**	Data taking Realization Simulation
4. **Cosmic matter research with nuclear physics methods**	**V.N. Shvetsov (FLNP)**	Data taking Realization Simulation
FLNP	A.Yu. Dmitriev, P.V. Sedyshev, M.V. Frontasyeva	

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
	Iaşi	UAIC
Russia	Moscow	IGEM RAS
		IKI RAS

		MSU
		PIN RAS
		SAI MSU
	Borok	IPE RAS
	Gatchina	NRC KI PNPI
	Novosibirsk	BIC SB RAS
United Kingdom	Buckingham	UB
USA	Athens, AL	ASU

04–2–1132–2017/2019	Priority: 1

Status: Being concluded

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.

Issues addressed and main goals of research:

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

Expected major results in the current year:

- 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 K.Sh. Voskanyan	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**	**G.V. Mitsyn** **K.Sh. Voskanyan**	R&D
DLNP	A.V. Agapov, I.V. Alexandrova, K. Belokopytova, V.M. Breyev, D.M. Borovich, T.L. Demakova, G.V. Donskaya, V.N. Gaevsky, A.E. Ivanova, Ye.I. Luchin, I.I. Klochkov, I.Ye. Miller, A.G. Molokanov, K. Oancea, S.A. Pisareva, A.V. Rzyanina, K.N. Shipulin, M.A. Tseytlina	
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**	R&D
DLNP	M.V. Alexandrova, K.P. Afanasyeva, S.V. Dubovik, N.E. Kharchenko, S.V. Korablinova, L.N. Korovina, Ye.V. Kravchenko, N.E. Kharchenko, E.S. Mayarova, N.V. Orlova, A.N. Rusakovich	

Collaboration

Country or International Organization	City	Institute or Laboratory
Czech Republic	Řež	UJV
	Prague	PTC
India	Mumbai	BARC
	New Delhi	IUAC
Moldova	Chişinău	MSU
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

04–2–1126–2015/2020	Priority: 1
	Status: In-progress

Novel Semiconductor Detectors for Fundamental and Applied Research

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

Participating countries and international organizations:

Belarus, CERN, Cuba, Croatia, Czech Republic, Germany, Italy, New Zealand, Romania, Russia, South Africa, Switzerland, United Kingdom, USA.

Issues addressed and main goals of research:

development of the existing scientific and technical base for R&D of semiconductor radiation-resistant detectors and hybrid high-resolution pixel detectors based on new semiconductor materials and Medipix readout chips for physical studies. development of the existing infrastructure for characterization of semiconductor detectors created at JINR and laboratories of the participating countries, in conjunction with beam tests at the JINR basic facilities. Conducting joint investigations in collaboration with research groups from other scientific centers to determine the potential of using the developed detectors and technologies in other fields of science and technology, especially in geology and biomedicine.
Upgrade the electron accelerator Linac–200 up to 800 MeV and to create a research infrastructure for studies at its test beams. Use of the facility for applied research and for practical trainings of students and PhD students - future engineers from JINR member states.
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.
Development and construction of setups for experiments at accelerators for obtaining new information and testing the present theoretical views in the strong, weak and electromagnetic interactions of elementary particles and light nuclei at intermediate energies with the aim of determining symmetries and dynamics of the interaction.

Expected major results in the current year:

- Data taking and analyze the information from GaAsPix system for radiation background monitoring in ATLAS.
- Study of the radiation hardness of GaAs:Cr.
- Measurement response of Timepix detectors and development the method of particle identification.
- Upgrade of the existing stations for measuring properties of semiconductor detectors.
- Installation in a MARS microtomograph pixel detector with larger size and magnification.
- Construction microtomograph with a fixed large area detector and a rotating specimen.
- Development of a full-featured readout electronics unit for Timepix and preparation for the creation of detectors based on the Medipix4 chip.
- Development of methods for spectral microtomography, including the improvement of computational algorithms.
- CT scan bio samples in cooperation with medicine expert.
- Studies of the possibility of isolating radiopaque substances in the body according to the energy dependence of the linear attenuation coefficient.

- CT scan of ores and mineral raw materials in cooperation with geophysicist.
- Upgrade of the vacuum system at A01–A04 stations of Linac–200.
- Development of the ACS.
- Start of practice at the "training" beam
- Creation a test version of the device forming an orderly flux of positrons.
- Experiments with the Active Target (GDH).

List of projects:

Project	Leader	Priority (period of realization)
1. Novel semiconductor detectors for fundamental and applied research	G.A. Shelkov	1 (2015 – 2020)
2. PAS Development of the experimental techniques and applied research with slow monochromatic positron beams	A.G. Kobets P. Horodek Scientific leader: I.N. Meshkov	1 (2016 – 2020)
3. 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. **Project "Novel semiconductor detectors for fundamental and applied research"**	**G.A. Shelkov** **A.S. Zhemchugov**	Realization
DLNP	V. Andriiashen, E.A. Cherepanova, M.A. Demichev, D.V. Dedovich, A. Gongadze, M.I. Gostkin, A.V. Guskov, S.A. Kotov, D.A. Kozhevnikov, V.G. Kruchonok, N.K. Kuznetsov, A.V. Lapkin, A. Leyva, A.A. Nozdrin, V.N. Pavlov, S.Yu. Porokhovoy, S. Shakur, P.I. Smolyansky	
FLNR	S. Mitrofanov	
VBLHEP	A.V. Averianov, S.V. Gertsenberger, A.M. Korotkova, D.O. Krivenkov, J. Lukstins	
2. **Project Development of the experimental techniques and applied research with slow monochromatic positron beams (PAS)**	**A.G. Kobets** **P. Horodek**	Realization
DLNP	E.V. Ahmanova, V.I. Hilinov, I.N. Meshkov, O.S. Orlov, A.Yu. Rudakov, A.A. Sidorin, K. Siemek, L.V. Soboleva, T.A. Stepanova, S.L. Yakovenko	
VBLHEP	V.M. Drobin, V.V. Seleznev	

3.	**GDH&SPASCHARM Project**	**Yu. Usov** **A. Kovalik**	Data taking Data processing
	DLNP	N.S. Borisov, N.A. Bazhanov, A.S. Dolzhenkov, A.N. Fedorov, I.V. Gapienko, I.S. Gorodnov, V.A. Kashevarov, A.B. Lazarev, A.B. Neganov, Yu.A. Plis, A.B. Sadovsky	
	BLTP	S.B. Gerasimov, S.S. Kamalov	
4.	**Use of new semiconductor photodetectors in a calorimetry for high energy physics**	**N.V. Anfimov**	Realization
	DLNP	A.I. Antoshkin, I.E. Chirikov-Zorin, V.V. Chalyshev, A.G. Olshevskiy, I.A. Orlov, T.V. Rezinko, A.V. Rybnikov, A.S. Selunin, D.V. Fedoseev	
	VBLHEP	T.Yu. Bokova, Z.Ya. Sadygov, I.A. Tyapkin	
5.	**Development of facility for measurement with test electron beams at DLNP. LINAC–200**	**A.G. Kobets** **M.I. Gostkin** **G.D. Shirkov**	Realization
	DLNP	E. Acosta, V.Yu. Baranov, A.E. Brukva, J.A. Budagov, Yu.I. Davidov, Dyatlov, D.V. Demin, N.I. Garanzha, K.I. Gritsay, V.V. Glagolev, V.D. Korovyakov, A.V. Krasnoperov, A.A. Nozdrin, S.Yu. Porokhovoy, A.V. Skrypnik, A.G. Sorokin, V.G. Shabratov, D.S. Shokin , K.E. Yunenko, A.S. Zhemchugov	
	VBLHEP	A.S. Sledneva	
	UC	D.S. Belozerov, K.B. Gikal, M.A. Nozdrin, K.A. Verlamov, D.A. Zlydenny	

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Belarus	Minsk	BSTU
Croatia	Zagreb	RBI
Cuba	Havana	CEADEN
Czech Republic	Prague	CTU
CERN	Geneva	CERN
Switzerland	Basel	Uni Basel
Germany	Hamburg	DESY
	Mainz	JGU
	Bonn	UniBonn
	Giessen	JLU
Italy	Pavia	INFN
New Zealand	Christchurch	UC
Poland	Krakow	NINP PAS
Romania	Bucharest	ISS
Russia	Dubna	Dubna State Univ.
	Moscow	MSU

	Moscow, Troitsk	INR RAS
	Arkhangelsk	NArFU
	Tomsk	TSU
	St. Petersburg	SPbSPU
South Africa	Cape Town	iThemba LABS
Ukraine	Kharkov	ISMA NASU
		IERT NASU
United Kingdom	Edinburgh	Univ.
USA	Washington, DC	UW

Networking, Computing, Computational Physics (05)

05–6–1118–2014/2019	Priority: 1

Status: Being concluded

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.

Issues addressed and main goals of research:

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 major results in the current year:

- Putting into service additional 100 Gbps telecommunication data links JINR-Moscow. Provision of the reliable operation of JINR local network. Transition of the JINR Backbone to 100 Gbps. Provision of "Personal Cabinet"and SSO services.

  Completion of work on the system of redundant power supply and uninterrupted power supply of the MICC infrastructure. Putting into service new infrastructure modules in the MICC computer hall to create optimal climate conditions for the equipment. Development of the project on fire safety for the engineering infrastructure of MICC.

  Building-up of the base grid-component of MICC-Tier1 centre for the CMS experiment at JINR: 52% growth of CPU capacity , 20% - disk storage and 100% - tape storage.

  Expansion of the computer resources and data storage as part of the integral component of Tier 2/CICC - 27% growth of processor capacity and 26% - disk storage.

  Introduction of services for managing supercomputer “Govorun” and monitoring the resources and tasks into the software and information environment of the heterogeneous computational platform HybriLIT. User’s personal cabinet elaboration. Development of service for using application software packages and mathematical software with advanced graphical interfaces on the HybriLIT platform.

  Expansion of the resources of the cloud-based component foresees 28% increase in the number of cores, 30% growth of RAM and 33% - disk storage capacity. Increase in quotas for cloud resources for experiments underway at JINR (NICA, BESIII, NOvA, Daya Bay, JUNO, Baikal-GVD, COMPASS, etc.) and the JINR Member States.

  Putting into service a “data lake” (common data warehouse) of the JINR MICC on the basis of IOS and dCache systems. Creation of a distributed storage system on the basis of EOS file system for offline cluster of the NICA megaproject in MICC and VBLHEP.

  Testing in the real software-computing environment of the “Govorun” supercomputer, the computing models for the NICA mega-project that satisfy the requirements to the time characteristics of receiving data from detectors with their subsequent transfer for processing, analysis and storage as well as the requirements to the efficiency of modeling and processing events in the experiment.

  Implementation of a server monitoring system for heterogeneous cluster HybriLIT and supercomputer “Govorun”. Provision of monitoring subsystems for the supercomputer’s engineering infrastructure (cooling system, power supply, leakage sensors), cooling towers, diesel generators and their integration into the existing monitoring system of the MICC.

- Development of an EDS "Dubna" version adapted for mobile devices. Improvement of existing modules and development of new ones for administrating the EDS "Dubna", in particular the development of modules "Designer of forms of documents", "The Coordination route template designer ". Modernization of the subsystem of the document routing on the basis of the analysis of problems and bottlenecks. Installation and refinement of new documents: "Order on the admission of persons invited to visit JINR" and integration of this document with the CHI system, "Secondment order", "Supplier invoice" and others.

  Transition of systems EDS "Dubna", PIN, ADB2, "Document Base" to the user authentication via SSO (Single sign-on) system, integration with "User's personal cabinet". Revision of the PIN system to enhance its protection against hacking and unauthorized access to information.

  Development of the project management system APT EVM for NICA, ADB2 systems, EDS "Dubna", ISS, "Document Base" in accordance with decisions of the working group on the development of the JINR information systems. Current support of EDS "Dubna", APT EVM for NICA, ADB 2, ISS, "Document Base", PIN.

  Continuation of cooperation with partner institutions on the JOIN2 project (Just anOther INvenio INstance), development of the JINR Document Server repository infrastructure based on the JOIN2 software platform. Maintenance of program libraries JINRLIB, CERNLIB and CPC. Provision of access to the software and data of NEA OECD Bank.

  Development and maintenance of the central information servers and portals to provide information and software support of JINR's activity.

  Development and support of the services for the information and computing environment of the "Govorun" supercomputer including installation and maintenance of specialized libraries and packages on users' request.

  Creation of a library of licensed software for the structural subdivisions of JINR.

- Conducting regular training courses and tutorials for JINR employees, students and young scientists from the JINR Member States on advanced information technologies, including Big Data, distributed, cloud and parallel programming technologies, tools and means of application development for computations on hybrid computing architectures on the basis of the education and research grid-cloud infrastructure and the education and test polygon HybriLIT. Organizing and conducting special courses of the leading software developers. Conducting student schools on information technologies in frames of the conferences held by LIT JINR as well as special training courses in the JINR Member States in the framework of the programmes on 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	Gh. 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, Yu.A. Butenko, 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, 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	Yu.P. Minaev, O.V. Rogachevsky, B.G. Shchinov, S.V. Shmatov
FLNP G.A. Sukhomlinov	
LRB V.N. Chausov	
FLNR V.V. Sorokoumov	A.G. Polyakov
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	**P.V. Zrelov** **V.V. Korenkov** **I.A. Filozova**
LIT	T.O. Ablyazimov, N.A. Balashov, A.V. Baranov, D.V. Belyakov, N.A. Davyudova, S.V. Duchits, V.P. Gerdt, T.M. Goloskokova, D.S. Golub, N.V. Jerusalimova, 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, T.S. Syresina, N.N. Vorobieva, V.M. Yagafarova, A.G. Zaikina, T.N. Zaikina
SOICO A.S. Sorin	V.F. Borisovskiy

VBLHEP
Yu.K. Potrebenikov

A.V. Philippov, K.V. Turusina

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)**

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

LIT

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	IIAP NAS RA
		YSU
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	BSTU
		INP BSU
		JIPNR-Sosny
		NASB
Bulgaria	Sofia	INRNE BAS
		SU
CERN	Geneva	CERN
China	Beijing	IHEP CAS
Czech Republic	Prague	IP CAS
Egypt	Giza	CU
France	Marseille	CPPM
Georgia	Tbilisi	GRENA
		GTU
		TSU
Germany	Darmstadt	GSI
	Frankfurt/Main	Univ.
	Hamburg	DESY
	Karlsruhe	KIT
	Zeuthen	DESY
Italy	Bologna	INFN
Kazakhstan	Astana	BA INP
		ENU
		NULITS

	Almaty	INP
Moldova	Chişinău	ASM
		IAP ASM
		RENAM
Mongolia	Ulaanbaatar	NUM
Poland	Krakow	CYFRONET
Romania	Bucharest	IFA
		IFIN-HH
	Cluj-Napoca	INCDTIM
Russia	Moscow	FRC IM RAS
		IITP RAS
		ISP RAS
		ITEP
		KIAM RAS
		MPEI
		MSU
		NRC KI
		RCC MSU
		RIPN
		RSCC
		SINP MSU
	Moscow, Troitsk	INR RAS
	Chernogolovka	SCC IPCP RAS
		LITP RAS
	Dubna	Dubna State Univ.
		SCC "Dubna"
		SEZ "Dubna"
	Gatchina	NRC KI PNPI
	Nizhny Novgorod	UNN
	Novosibirsk	BINP SB RAS
	Pereslavl-Zalesskiy	PSI RAS
	Protvino	IHEP
	Puschino	IMPB RAS
	Samara	SU
	St. Petersburg	FIP
		ITMO
		SPbSU
		SPbSPU
Slovakia	Košice	IEP SAS
	Prešov	PU
South Africa	Cape Town	UCT
Sweden	Lund	LU
Taiwan	Taipei	ASGCC
Ukraine	Kiev	BITP NASU
	Kharkov	NSC KIPT

USA	Arlington, TX	UTA
	Batavia, IL	Fermilab
	Upton, NY	BNL

05–6–1119–2014/2019	Priority: 1

Status: Being concluded

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, Belarus, Brazil, Bulgaria, Canada, CERN, China, Czech Republic, France, Georgia, Germany, United Kingdom, India, Italy, Japan, Kazakhstan, Lithuania, Moldova, Mongolia, Poland, Romania, Russia, Saudi Arabia, Slovakia, South Africa, Switzerland, Tajikistan, USA, Vietnam.

Issues addressed and main goals of research:

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 major results in the current year:

- Numerical investigation of model equations defining baryon behavior at NICA energies.

  Three-dimensional computer simulation of magnetic field distributions in superconducting dipole and quadrupole magnets for the projects NICA (JINR) and FAIR (GSI).

  Monte-Carlo simulations of gauge-invariant observables within the lattice SU(2) gluodynamics under various boundary conditions.

  Improvement of QGSM generator aimed at including experimental effects in the strange and dilepton particle yields.

  Development of numerical and analytical methods for computing the ionization spectra of hydrogen like hadronic atoms in the eikonal approximation.

  Modeling the extremely high energy electromagnetic showers analyzed in a number of ultra-high energy neutrino astrophysics projects such as Baikal, IceCube, and Antares.

  Analysis of interactions of stable and exotic nuclei with nuclei and protons on the basis of microscopic approach, including reactions $^{12,14}Be + ^{12}C$ and $^{12,14}Be + p$.

  Numerical investigation of complex physical processes described by multi-parameter systems of nonlinear equations.

  Transport approach based modeling of heavy-ion collisions in the Fermi energy range and its use in the analysis of COMBAS data.

  Numerical modeling of fast magnetization reversal due to the influence of external alternating fields on the effective magnetic anisotropy.

  Computer simulation of spin dynamics in dipole and spinor systems and numerical study of the influence of the quadratic Zeeman effect on spin dynamics.

Calculation of beam dynamics, measurement of the Smith-Garren curves and their recalculation as phase motion curves with the aim of evaluating the quality of formation of magnetic fields and their correction for the isochronous cyclotrons AIC-144 (Krakow, Poland), SC-200 (Hefei, China), DC-280 (FLNR, JINR).

Analysis of the measured magnetic field maps, calculations of beam dynamics and comparison of the results with those on simulated magnetic field maps (TOSCA, CST).

Development of numerical methods and algorithms for the study of phase transitions arising in materials under ion beam irradiation for parabolic and hyperbolic heat conduction equations.

Development and support of the primary data processing program "SAS" for the YuMO spectrometer at IBR-2M. Development and support of the new data converter "PSD2SAS" for position-sensitive detector in isotropic pattern scattering case. Development of algorithms for data analysis for anisotropic pattern scattering samples. Visualization and fitting of three-dimensional data records. Development of the basic elements method for solving problems of the contour analysis. Development of the basic elements method for solving problems of the contour analysis.

Development of methods, algorithms and programs for forecasting atmospheric pollution in the tasks of environmental monitoring based on machine learning.

Development of mathematical methods for resolving fine structure distributions with respect to mass and energy of the nuclear reaction products.

Least action control in Bayesian automatic adaptive quadrature.

Analysis of soliton-bearing PT-symmetric spinor systems of condensed matter physics.

Study of soliton solutions of the damped-driven repulsive nonlinear Schroedinger equation and their application to the analysis of the soliton-mediated frequency combs.

Calculation and optimization of the magnetic field configurations of the large superconducting magnet of the SPD setup within the NICA project.

Numerical analysis by quantum chemistry methods of exchange interactions in crystalline iridium-oxide compositions with varying geometry of local bonds. Development and use of a program package of the quasi-phonon model of the nucleus for the study of the properties of heavy exotic nuclei. Development and use of a program package of the quasi-phonon model of the nucleus for the study of the properties of heavy exotic nuclei.

- Improvement of the FTF model of the Geant4 package and refinement of its parameters for simulation of proton-nuclear and core-nuclear interactions at intermediate energies within the joint project of PANDA and HADES collaborations - Phase-0 and Phase-1 (GSI).

  Simulation of proton-proton and deuteron-deuteron interactions at nucleon-nucleon collision energies of 3-15 GeV (in the center of mass system) in the framework of the FTF model of the Geant4 package for the NICA/SPD experiment. Adaptation of the FTF model for inelastic interactions in the computing environment of the NICA/SPD experiment - SPDRoot.

  Development of Geant4 FTF model for modeling nuclear-core interactions in a wide range of energies and analyzing experimental data at BM@N (JINR) and NA61/SHINE, and planning experiments for CBM (GSI) and MPD (JINR/NICA).

  Participation in design of data bases for NICA project. Participation in design of online DAQ system for NICA project.

  Commissioning the Geometry Database for the CBM experiment. Development of a database concept for useful events selected in the CBM experiment.

  Software support of ATLAS experiment, agreed with the ATLAS computing team: support of online TDAQ ATLAS components that was implemented in LIT; support and improvement of tool for ATLAS network monitoring dashboards; creation and support of Monitoring for ATLAS EventIndex project; participation in modernization of ATLAS condition databases for RUN3, design and implementation conversion tools from COOL data to CREST data.

  Development of algorithms for processing experimental data acquired with the planes of microstips tracking detectors (GEM and SILICON) for the current configuration of the BM@N/NICA setup.

Development of software for detailed simulation of physics processes occurring in gaseous and semiconductor detectors of the main tracking system in the BM@N/NICA experiment. BM@N: Reconstruction of trajectories and identification of charged particles using tracking and time-of-flight detectors.

Investigations on the possibility to construct effective neural net algorithms for event reconstruction in TAIGA experiment.

Experiment NUCLEON: Development of a program for the analysis of data on the anisotropy of the cosmic rays. Investigation of additional possibilities of modified data analysis schemes of records from heavy leaky calorimeters.

BM@N experiment: Experimental data processing of GEM detector data under improved impulse reconstruction of charged particles. Use of the obtained results for the reconstruction of the decays of short-lived strange and multistrange baryons.

CMS: Further development and testing of the algorithm of overlapped signal separation in CSC and its implementation into official CMS release; assessment of CSC performance (efficiency and resolution) with new LHC data; completion of CSC ageing studies on muon beam tests with radiation source (CERN Gamma Irradiation Facility (GIF++)).

Investigation of structure and properties of polydispersed vesicles of phospholipids by analysis of experimental data on the small angle acattering of neutrons and x-rays.

High order mean-square piecewise polynomial approximation based analysis of the slow noise changes of the power of the IBR-2M reactor.

BAIKAL project: Development of the data acquisition software. Development of alert system.

Further development of VMRIA software package for large data set automatic analysis in experiments carried out on the High Resolution Fourier Diffractometer at IBR-2M.

Development of methods and software for automatic calibration of multi-detector systems.

Further development of statistical non-parametrical methods for parameter estimation and hypothesis testing under low data statistics and process observation incompleteness.

Development of methods for the simulation of the reflection of neutrons from layered nanostructures.

Development of criteria and methods for selection of exotic nuclei in the CBM experiment.

Development of triggers for recording rare decays of J/ψ in the dielectron and dimuon channels in the CBM experiment.

Investigation of statistical features of the Internet traffic. Analysis of external impact on the statistical characteristics of the information traffic.

Development of FPGA programs as part of reading and data acquisition electronics for CBM experiment.

Go4 user library upgrade for the data aquisition system for the experiments at the fragment-separator ACCULINNA-2 at FLNR.

Development of the FAIRroot based package EXPERtroot for simulation and data analysis for the experiments at the fragment-separator ACCULINNA-2 at FLNR.

Calculation of electrostatic potentials for Zn protein transcription factors.

Development of new methods for computation of kinetic, thermodynamic, and optical parameters of intermediate compunds in reactions of transition metal ions with heterocyclic compounds.

- Development and support of the information-computing environment of the heterogeneous platform HybriLIT including installation and maintenance of specialized libraries and application software packages.

  Optimization and analysis of the performance of developed packages of parallel programs using various parallel programming techniques.

  Modeling processes of single and multiple ionization/photoionization of the water molecule.

  Study of helium single ionization by fast proton impact in different kinematic regimes.

  Development and implementation of new parallel algorithms for computations on hybrid architectures, including Intel Xeon Phi (KNL) processors and NVIDIA graphics accelerators.

Development and support on the cluster HybriLIT of a program devoted to particle identification in the search for anomalous lepton.

Study of the efficiency of various parallelization techniques implemented in the ROOT package, when computing on the heterogeneous HybriLIT cluster.

Maintenance of the information site created to support the ROOT users at JINR.

Optimization of software developed for solving NICA project problems on multiprocessor computing systems.

Development of algorithms and program modules of optimal h-p discretization by discontinuous least-squares method for parallel solving nonlinear magnetostatic problems.

Conducting research with the aim of reconciling the continuous thermal spike and molecular dynamics models for the description of thermoelastic processes under sample irradiation with heavy ion beams.

Fast FEM algorithm for numerical solution of the 3D magnetostatic problems in COMSOL Multiphysics environment capable of yielding the high accuracy field maps for dipole magnets with superconducting coils.

Analysis of the 3D thermo-electric modelling of the quench initiating and propagating in the superconducting coils and its precise detection for various cooling conditions based on the COMSOL Multiphysics ®.

Development of methods and parallel algorithms for the reconstruction of the tracks of elementary particles based on neural networks with deep learning for the objectives of the project NICA.

Formulation of the optimization problem for the nonlinear heat equation and development of parallel algorithms for solving it in hybrid computing architectures.

Development of new effective algorithms for improving LDPC decoding performance.

- Development of an algebraic method for constructing quasi-probability distributions of composite finite-dimensional quantum systems.

Analysis of the interplay between the negativity of the Wigner functions quasi-probability and the entanglement for mixed quantum states of finite-dimensional quantum systems.

Development of algorithmic methods for constructing the first differential approximation (modified equations) of difference schemes for systems of quasilinear partial differential equations with polynomial nonlinearity.

Construction of data structures for systems of nonlinear algebraic equations which admit efficient parallelization and implementation on the heterogeneous cluster HybriLIT of algorithms for the transformation of such systems to canonical involutive forms.

Creation of algorithms and programs for the analysis of metastable and bound states of a Beryllium trimer with realistic pair interactions in a collinear configuration.

Creation of algorithms and programs for generating orthonormal Bargmann-Moshinsky basis for the evaluation of spectra of the collective nuclear model.

Development of an effective algorithm for irreducible component splitting of unitary group representations describing quantum systems.

New compact formulae for the one-loop 3, 4, 5 and 6-point Feynman integrals in arbitrary space -time dimension.

List of activities:

	Activity or experiment **Laboratory or other Division of JINR**	**Leaders** **Main researchers**
1.	**Mathematical and computation methods for simulation of complex physical systems**	**Gh. Adam** **I.V. Puzynin**

LIT	S. Adam, R. Akhat, P.G. Akishin, I.V. Amirkhanov, E.A. Ayrjan, I.V. Barashenkov, A.A. Bogolubskaya, I.L. Bogolubsky, N.D. Dikoussar, H. Grigorian, M. Kakenov, Yu.L. Kalinovsky, T.V. Karamysheva, N.A. Kutovskyi, K.V. Lukyanov, N.V. Makhaldiani, T.I. Mikhailova, G.J. Musulmanbekov, A.V. Nechaevsky, K. Oganesyan, G.A. Ososkov, R.V. Polyakova, B. Saha, I. Sarkhadov, N.Yu. Shirikova, A.G. Soloviev, T.M. Solovieva, L.A. Siurakshina, A.V. Uzhinsky, A.V. Volokhova, O.O. Voskresenskaya, A. Wojczechowski, R.M. Yamaleev, E.P. Yukalova, E.V. Zemlyanaya
VBLHEP	S. Gevorkyan, M.N. Kapishin, A.O. Kechechyan, H.G. Khodzhibagiyan, A.D. Kovalenko, E.E. Perepelkin, O.V. Rogachevski, V. Zhezher
BLTP	D. Blaschke, A.V. Friesen, M. Hnatic, E.-M. Ilgenfritz, R.V. Jolos, V.K. Lukyanov, A.V. Sushkov, V.D. Toneev, V.I. Yukalov, V.Yu. Yushankhai
FLNR	A.G. Artukh, B. Erdemchimeg, S.M. Lukyanov, Yu.E. Penionzhkevich, Yu.V. Pyatkov+1, Yu.M. Sereda, Yu.G. Sobolev
FLNP	M.V. Frontasyaeva, O.I. Ivankov, A.I. Kuklin, D.V. Soloviev, 3 pers.
DLNP	L.G. Afanasiev, S.N. Dolya, G.A. Karamysheva, I.N. Kiyan, V.A. Malinin, D.V. Popov
2. **Software complexes and mathematical methods for processing and analysis of experimental data**	**P.V. Zrelov** **V.V. Ivanov**
LIT	T.O. Ablyazimov, E.P. Akishina, E.I. Aleksandrov, I.N. Aleksandrov, D.A. Baranov, S. Belogurov, O.Yu. Derenovskaya, N.D. Dikoussar, I.A. Filozova, A.A. Kazakov, A.I. Kazymov, P.I. Kisel, B.F. Kostenko, G.E. Kozlov, L.Yu. Kruglova, A.A. Lebedev, M.A. Mineev, E.V. Ovcharenko, V.I. Palichik, R.V. Polozov, I. Satyshev, V.N. Shigaev, S.K. Slepnev, A.G. Soloviev, T.M. Solovieva, A.N. Sosnin, V.V. Uzhinsky, N.N. Voitishin, O.O. Voskresenskaya, A.V. Yakovlev, E.V. Zemlyanaya, E.I. Zhabitskaya, V.B. Zlokazov
VBLHEP	P.N. Batyuk, B.V. Batyunya, Yu.V. Ershov, A.S. Galoyan, K.V. Gertsenberger, A.O. Golunov, I.A. Golutvin, N.V. Gorbunov, A.Yu. Kamenev, M.N. Kapishin, V.Yu. Karzhavin, V.P. Ladygin, V.V. Lenivenko, A.M. Makan'kin, A.I. Malakhov, S.P. Merts, S.A. Movchan, A.N. Morozov, V.V. Perelygin, Yu.P. Petukhov, O.V. Rogachevsky, M.M. Rumyantsev, M.G. Sapozhnikov, V.N. Shchetinin, V.N. Spaskov, N.D. Topilin, S.E. Vasiliev, A.V. Zarubin
FLNR	A. Fomichev, S. Belogurov, V. Chudoba, Yu.S. Tsyganov, V.K. Utenkov

	FLNP	A.M. Balagurov, A.V. Belushkin, I.A. Bobrikov, M.A. Kiselev, D.P. Kozlenko, S.A. Manoshin, Yu.N. Pepelyshev
	DLNP	I.V. Bednyakov, V.A. Bednyakov, I.A. Belolaptikov, V.B. Brudanin, A.G. Olshevsky, D.B. Pontecorvo, B.A. Shaibonov, L.G. Tkachev, A.S. Zhemchugov
	UC	S. Pakuliak
3. **Numerical methods, algorithms and software computationally adapted to multicore and hybrid architectures**		**Gh. Adam** **P.V. Zrelov** **O.I. Streltsova**
	LIT	E.I. Aleksandrov, A.S. Ayriyan, D.A. Baranov, M.V. Bashashin, D.V. Belyakov, J. Busa, Yu.A. Butenko, A.M. Chervyakov, O. Chuluunbaatar, H. Grigorian, A.A. Gusev, M. Kirakosyan, D.V.A. Luu, M.A. Matveev, S.V. Mitsyn, G.A. Ososkov, D.V. Podgainy, T.P. Puzynina, V.S. Rikhvitsky, A.A. Sapozhnikov, T.F. Sapozhnikova, N.R. Sarkar, 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, T.N. Zaikina, E.V. Zemlyanaya, E.I. Zhabitskaya, M.I. Zuev
	LIT-MICC	V.V. Korenkov, V.V. Mitsyn, T.A. Strizh
	FLNR	N.Yu. Kazarinov, R.A. Rymzhanov, V.A. Skuratov
	BLTP	D.B. Blashke, S.N. Nedelko, Yu.V. Popov, Yu.M. Shukrinov, S.I. Vinitsky
	VBLHEP	A.V. Belyaev, A.Yu. Boytsov, E.E. Donets, I.V. Golutvin, V.A. Nikitin, O.V. Rogachevsky, 2 pers.
	DLNP	G.A. Karamysheva, G.D. Shirkov, Yu.Yu. Stepanenko
	FLNP	E.B. Askerov
4. **Methods, algorithms and software of computer algebra**		**V.P. Gerdt**
	LIT	V. Abgaryan, A.A. Bogolubskaya, O. Chuluunbaatar, A.A. Gusev, A.M. Khvedelidze, V.V. Kornyak, Yu. Palii, A.M. Raportirenko, I.A. Rogozhin, O.V. Tarasov, A.G. Torosyan, D.A. Yanovich
	BLTP	A.V. Czhizhov, P. Fiziev, D.I. Kazakov, V.S. Melezhik, A.I. Titov, S.I. Vinitsky
	FLNR	B.N. Gikal

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL IIAP NAS RA

		RAU
		YSU
Belarus	Minsk	IM NASB
	Gomel	GSTU
Brazil	Sao Carlos, SP	IFSC USP
Bulgaria	Sofia	IMI BAS
		INRNE BAS
		SU
	Plovdiv	PU
Canada	Toronto	IBM Lab
	Edmonton	U of A
CERN	Geneva	CERN
China	Nanning	GUFN
Czech Republic	Prague	CTU
France	Metz	UPV-M
Georgia	Tbilisi	GTU
		TSU
		UG
Germany	Bonn	UniBonn
	Darmstadt	GSI
	Dresden	IFW
	Frankfurt/Main	Univ.
	Hamburg	Univ.
	Kassel	Uni Kassel
	Munich	LMU
India	Kolkata	JU
Italy	Bari	UniBa
Japan	Osaka	Kansai Univ.
	Saitama	SU
Kazakhstan	Almaty	INP
Lithuania	Kaunas	VMU
Moldova	Chişinău	MSU
Mongolia	Ulaanbaatar	IPT MAS
		NUM
		MUST
Poland	Krakow	NINP PAS
	Lublin	UMCS
	Otwock-Swierk	NCBJ
	Warsaw	WUT
	Wroclaw	UW
Romania	Bucharest	IFA
		IFIN-HH
		ISS
		UB
	Cluj-Napoca	INCDTIM

	Timişoara	UVT
Russia	Moscow	GPI RAS
		ITEP
		JIHT RAS
		KIAM RAS
		MIET
		NIFHI
		NNRU "MEPhI"
		NRC KI
		PFUR
		RCC MSU
		SINP MSU
	Dolgoprudny	MIPT
	Dubna	Dubna State Univ.
	Gatchina	NRC KI PNPI
	Perm	PSNRU
	Protvino	IHEP
	Puschino	IMPB RAS
		IPR RAS
	Saratov	SSU
	St. Petersburg	NIIEFA
	Tomsk	TSU
Saudi Arabia	Tuval	KAUST
Slovakia	Košice	IEP SAS
		PJSU
		TUKE
	Banska Bistrica	UMB
South Africa	Cape Town	UCT
	Stellenbosch	SU
Switzerland	Zurich	ETH
Tajikistan	Dushanbe	PHTI ASRT
		TNU
	Khujent	KSU
United Kingdom	Bath	UB
	London	Imperial College
USA	Cambridge, MA	MIT
	Davis, CA	UCDavis
	Durham, NC	NCCU
	Los Alamos, NM	LANL
Vietnam	Hanoi	VNU

05–8–1037–2001/2019	Priority: 1

Status: Being concluded

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, states participating in JINR activities on the basis of bilateral agreements, international organizations.

Issues addressed and main goals of research:

Development of analytical materials concerning prospects of scientific research. Preparation of scientific research plans. Development of science-organization and methodological materials for the special-purpose financing of research areas, themes and projects. Development and application of information systems for the analysis of results of theoretical and experimental research. Organization of international cooperation with the Member States of JINR, with states participating in JINR activities on the basis of bilateral agreements, and with scientific research institutions with which JINR has collaboration agreements.

Expected major results in the current year:

- Improvement of the organization and coordination of JINR scientific research work.
- Analysis of the results of JINR activities for 2018 in the main research areas.
- Development of a new electronic system for maintaining the Topical Plan for JINR Research and International Cooperation (Topical Plan). Preparation for the publication of the Topical Plan for the year 2020. Identification of JINR's priority research directions for 2020.
- Development of JINR's grantmaking activities and participation in special-purpose programmes for financing scientific research in 2019.
- Preparation of analytical materials for ministries and agencies.
- Development and promotion of JINR's information resources on the Internet. Support of the system of protocols on scientific and technological cooperation.
- Study of scientific and organizational foundations for the establishment of a system of independent conferring of academic degrees at JINR. Support of the operation of JINR's existing dissertational councils.
- Preparation for the publication of the JINR Annual Report for 2018. Preparation of materials for the INIS system.
- Scientific and organizational support and preparation of materials of JINR's governing and advisory bodies.
- Prompt interaction with representatives of Member States and states participating in the activities of JINR on the basis of bilateral agreements in the field of scientific research. Organization and holding of meetings of cooperation committees. Interaction with international organizations.
- Organization and holding of contests for JINR Prizes, preparation of materials for nominating candidates for membership in academies of sciences, for conferring honorary titles, for awarding medals and other decorations.

List of activities:

Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers
1. **Development and preparation for the publication of the Topical Plan for 2020**	**A.S. Sorin** **O.V. Belov**
SOD	N.I. Sissakian, N.A. Boklagova, L.K. Ivanova, D.S. Korobov
2. **Organizational support and improvement of the operation of JINR's governing and advisory bodies**	**A.S. Sorin** **O.V. Belov** **D.V. Kamanin**
SOD	N.I. Sissakian, T.B. Ivashkevich, O.K. Kronshtadtov, D.S. Korobov
ICD	A.A. Kotova, N.M. Dokalenko, E.N. Rusakovich, O.N. Belova, O.M. Korotchik
ICC	M.N. Sidorchuk
HS	M.D. Kryukova
3. **Preparation of analytical materials for ministries and agencies**	**A.S. Sorin** **O.V. Belov** **D.V. Kamanin**
SOD	N.I. Sissakian, D.S. Korobov, T.B. Ivashkevich, N.A. Boklagova,
ICD	A.A. Kotova, A.E. Vasiliev
STL	E.V. Ivanova, V.V. Litsitis
4. **Development of JINR's grantmaking activities and participation in special-purpose programmes for financing scientific research**	**A.S. Sorin** **O.V. Belov** **D.V. Kamanin**
SOD	N.I. Sissakian, N.A. Boklagova, L.K. Ivanova, D.S. Korobov
5. **Support for the operation of the dissertation councils**	**A.S. Sorin** **O.V. Belov**
SOD	N.I. Sissakian, T.B. Ivashkevich,
6. **Organizational support for JINR's activities under Russian and international protocols and agreements**	**A.S. Sorin** **D.V. Kamanin** **O.V. Belov**
SOD	N.I. Sissakian, L.I. Kalinina
ICD	A.A. Kotova, T.V. Keselis

7. **Provision for the operation and development of JINR's Internet resources**	**A.S. Sorin** **O.V. Belov** **D.V. Kamanin**
SOD	N.I. Sissakian, K.P. Moisenz, A.G. Nanev, N.A. Boklagova, L.K. Ivanova, O.K. Kronshtadtov, D.S. Korobov
STD AMIS	V.F. Borisovsky
SID	B.M. Starchenko
ICD	A.A. Suschevich
Editorial office of the weekly newspaper "Dubna: science, community, progress"	E.M. Molchanov
LIT	K.V. Lukyanov, A.V. Prikhodko
8. **Preparation for the publication of JINR Annual Reports. Preparation of materials for the INIS system**	**A.S. Sorin**
SID	B.M. Starchenko, Yu.G. Shimanskaya, E.A. Pershina
9. **International cooperation**	**D.V. Kamanin** **W. Chmielowski**
ICD	A.A. Kotova, M.G. Loschilov, A.E. Vasiliev, O.N. Belova, T.V. Keselis, Yu.N. Polyakova

Educational Programme (06)

06–0–1139–2019/2023	Priority: 1
	Status: New

Organization, Support and Development of the JINR Human Resources Programme

Leaders: V.A. Matveev
S.Z. Pakuliak

Participating countries and international organizations:

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

Issues addressed and main goals of research:

Implementation of the training programmes in the fields of JINR research in order to facilitate the career building for scientific and engineering specialists at the Institute and at research organizations of the JINR Member States; creation of appropriate conditions for students and PhD students from universities of the Member States to enable them to work on their qualification theses; support of the educational process for students of the JINR-based departments from universities of the Russian Federation, as well as for the students sent to the UC from the Member States; organization international events including International student practices and international schools for young people from the JINR Member States; admission to the practical courses of undergraduate and postgraduate students and trainees on the basis of the cooperation agreements with international organizations and universities of the Member States; development and maintenance of educational laboratory utilities for specialized workshops on accelerator physics and nuclear physics; support and improvement of the licensed system of qualification development, professional skills gaining and mastering courses for JINR technical and engineering staff; development and promotion of outreach programmes on JINR and modern science achievements for school students and teachers, organization of excursions to the JINR basic facilities; further development of the JINR educational portal (edu.jinr.ru), development of virtual and real laboratories allowing students to be trained using modern experimental facilities; development of a set of e-learning courses on the main areas of research conducted at JINR, as well as on its basic facilities, participation in JINR promoting multimedia exhibitions.

Expected major results in the current year:

- Support of the educational process at the JINR-based departments of universities of the Russian Federation. Preparation and publication of the lecture courses as UC tutorials for students and postgraduates.
- Support of the system of assigning the Institute staff to work on their PhD theses at JINR without mastering postgraduate academic programmes.
- Coordination of the JINR Summer Student Programme, conduct of international schools and workshops for students, organization of international summer student practices for the JINR Member States. Expansion of scientific research directions of the projects for the JINR Summer Student Programme and increasing of the number of participants in the Programme.
- Development of the specialized workshop to conduct practical training on accelerator physics and nuclear physics performed on the basis of dedicated test-benches within the framework of functioning of the UC Scientific-Engineering Group established to implement the training programmes for engineering staff for the JINR laboratories and research centres in Member States. Organisation of JINR-based training for students of the International School of Engineering of Dubna University.
- Development and support of the computer infrastructure for implementing the training programmes in HEP data analysis and construction of modern physics facilities.

- Further development of the UC Physics Lab and of the Interschool Physics and Mathematics Open Classroom in order to organize lectures and hands-on activities in science for highschool students from the JINR Member States. Organization of scientific schools for physics teachers from the JINR Member States at CERN and at JINR.
- Organization of real excursions and virtual tours of JINR. Development of the Russian, English, French, and German courses for JINR staff.
- Development of e-learning courses in nuclear physics, particle physics, condensed matter physics, and in JINR basic facilities. Promotion of modern educationainal resources in the JINR Member States.
- Organisation of JINR's participation in the Moscow Science Festival "NAUKA 0+" 2019 to be held in the Lomonosov Moscow State University.

  Launch of the system of virtual tours of JINR and video conferences with educational institutions of JINR Member States.

  Participation of JINR in the interdisciplinary social and educational project "Summer School - 2019".

List of projects:

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

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers
1. **Organization of the Educational Process at JINR**	**V.A. Matveev** **S.Z. Pakuliak**
DLNP V.A. Bednyakov D.V. Naumov A.S. Zhemchugov	V.V. Glagolev, A.G. Olshevskiy, A.Yu. Verkheev
BLTP D.I. Kazakov A.P. Isaev A.B. Arbuzov	A.V. Gladyshev, Yu.M. Shukrinov
FLNP V.N. Shvetsov O.A. Culikov E.V. Lychagin	A.M. Balagurov, A.V. Belushkin, D.P. Kozlenko
VBLHEP V.D. Kekelidze E.A. Strokovsky D.V. Peshekhonov	V.A. Nikitin, Yu.A. Panebratsev, S.S. Shimansky
FLNR S.N. Dmitriev A.G. Popeko A.V. Karpov	S.G. Belogurov, S.I. Sidorchuk

LIT V.V. Korenkov T.A. Strizh D.V. Podgaynyi	V.P. Gerdt, I.S. Pelevanyuk, O.I. Streltsova
LRB E.A. Krasavin I.V. Koshlan	Yu.S. Severyukhin
Directorate B.Yu. Sharkov B.N. Gikal	A.V. Dudarev, E.D. Uglov
SOICO A.S. Sorin D.V. Kamanin A.A. Kotova	W. Chmielowski

2. **Developing of modern educational projects** — **Y.A. Panebratsev**

VBLHEP	G.N. Agakishiev, V.V. Belaga, E.I. Golubeva, N.E. Sidorov, X.V. Klygina, Yu.D. Orlova, M.P. Osmachko, P.D. Semchukov, G.A. Yarygin, N.I. Vorontsova

3. **Outreach programmes of JINR: popularisation of science and promotion of the achievements of JINR** — **S.Z. Pakuliak**, **A.A. Suschevich**

DLNP	N.V. Anfimov, M.V. Fomina, C. Kullenberg, M.V. Shirchenko, A.Yu. Verkheev
BLTP	A.V. Frizen
FLNP	K. Hramko
VBLHEP	A.S. Bogomolova, D.K. Dryablov, D.I. Klimanskii, C. Roslon, N.E. Sidorov
FLNR	K.B. Gikal, A.A. Voinov
LIT	I.S. Pelevanyuk, Sh.G. Torosyan
LRB	T.S. Bulanova, I.A. Kolesnikova, Yu.S. Severyukhin
JINR Universal Library	O.V. Gaponova, M.S. Pilipenko

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	YSU
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	BSU
		INP BSU
		ISEI BSU
		ME RB
	Gomel	GSU
Bulgaria	Sofia	INRNE BAS

		NRA
		SU
	Blagoevgrad	SWU
CERN	Geneva	CERN
Cuba	Havana	ASC
Czech Republic	Prague	CU
		CTU
Egypt	Cairo	ASRT
Kazakhstan	Almaty	KazNU
	Astana	ENU
	Ust-Kamenogorsk	EKSU
Moldova	Chişinău	ASM
Mongolia	Ulaanbaatar	NUM
Poland	Krakow	NINP PAS
	Lodz	UL
	Poznan	AMU
Romania	Bucharest	UB
Russia	Moscow	MPEI
		NNRU "MEPhI"
		SINP MSU
	Arkhangelsk	NArFU
		NSMU
	Belgorod	BelSU
	Dolgoprudny	MIPT
	Dubna	BSINP MSU
		Dubna State Univ.
	Ivanovo	ISU
	Krasnodar	KSU
	Kostroma	KSU
	St. Petersburg	SPbSU
	Smolensk	SSU
	Tomsk	TPU
	Tula	TSU
	Tver	TvSU
	Voronezh	VSU
	Yakutsk	NEFU
Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	CU
	Košice	PJSU
South Africa	Pretoria	DST
Ukraine	Kiev	BITP NASU
		NUK
USA	Upton, NY	BNL
Vietnam	Hanoi	IOP VAST
	Da Lat	DLU
		NRI

Alphabetic List of Collaborators

Albania

Tirana

UT (University of Tirana | http://www.unitir.edu.al/), 130

Argentina

Bariloche

CAB CNEA (Bariloche atomic Centre | http://www.cab.cnea.gov.ar/), 140, 149

Buenos Aires

CNEA (National Atomic Energy Commission | http://www.cnea.gov.ar/), 146

Armenia

Garni

GGO (Garni Geophysical Observatory), 90

Yerevan

CENS NAS RA (Center for Ecological-Noosphere Studies of the National Academy of Sciences of the Republic of Armenia | http://www.cens.am/), 130

Foundation ANSL (A.I.Alikhanian National Science Laboratory (Yerevan Physics Institute) Foundation | http://www.yerphi.am/), 13, 24, 41, 64, 98, 101, 104, 123, 183

IIAP NAS RA (Institute for Informatics and Automation Problems of the National Academy of Sciences of the Republic of Armenia | http://ipia.sci.am/), 24, 175, 183

Inst. Biochemistry NAS RA (H.Buniatian Institute of Biochemistry of the National Academy of Sciences of the Republic of Armenia | http://aab.sci.am/), 153

RAU (Russian-Armenian University | http://www.rau.am/), 13, 19, 184

Shirak Technologies ("Shirac" Technological Company | http://www.shte.net/), 90

YSU (Yerevan State University | http://ysu.am/), 19, 24, 29, 33, 84, 98, 108, 123, 160, 175, 184, 192

Australia

Melbourne

Univ. (University of Melbourne | http://www.unimelb.edu.au/), 24, 130

Perth

UWA (University of Western Australia | http://www.uwa.edu.au/), 29

Sydney

Univ. (University of Sydney | http://sydney.edu.au/), 24, 29, 108

Austria

Innsbruck

Univ. (University of Innsbruck | http://www.uibk.ac.at/), 19, 130

Linz

JKU (Johannes Kepler University Linz | http://www.jku.at/), 24

Vienna

HEPHY (Institute of High Energy Physics | http://www.hephy.at/), 64

IAEA (International Atomic Energy Agency | http://www.iaea.org/), 130

ITP TU Wien (Institute for Theoretical Physics Vienna University of Technology | http://www.tuwien.ac.at/), 33

TU Wien (Vienna University of Technology | http://www.tuwien.ac.at/), 24, 33

Azerbaijan

Baku

AzTU (Azerbaijan Technical University | http://aztu.edu.az/), 140

BSU (Baku State University | http://bsu.edu.az/), 130

Branch MSU (Branch of the Lomonosov Moscow State University | http://www.msu.az/), 24

IGG ANAS (Institute of Geology and Geophysics of the Azerbaijan National Academy of Sciences | http://irp.gia.az/), 130

IP ANAS (Institute of Physics of the Azerbaijan National Academy of Sciences | http://www.physics.gov.az/), 13, 41, 84, 140, 175, 192

IRP ANAS (Institute of Radiation Problems of the Azerbaijan National Academy of Sciences | http://irp.science.az/), 101, 146

NNRC (National Nuclear Research Center | http://www.mntm.az/), 104, 146

Ganja

ASAU (Azerbaijan State Agricultural University | http://adau.edu.az/), 130

ATU (Azerbaijan Technological University | http://www.aztun.edu.az/), 130

Belarus

Gomel

BNTU (Belarusian National Technical University, Branch of the Gomel | http://www.bntu.by/), 155

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

Belgium

Brazil

Niteroi, RJ
UFF (Federal Fluminense University | http:www.uff.br/), 19
Porto Alegre, RS
UFRGS (Federal University of Rio Grande de Sul | http:www.ufrgs.br/), 104
Rio de Janeiro, RJ
CBPF (Brazilian Center for Physics Research | http://portal.cbpf.br/), 64
UERJ (University of the State of Rio de Janeiro | http://www.uerj.br/), 64
UFRJ (Federal University of Rio de Janeiro | http://ufrj.br/), 64
Sao Carlos, SP
IFSC USP (Institute of Physics of São Carlos of the University of São Paulo | http://www.ifsc.usp.br/), 184
Sao Jose dos Campos, SP
ITA (Aeronautics Institute of Technology | http://www.ita.br/), 19
Sao Paulo, SP
UEP (Unit of Professional Education Santa Case de São Paulo | http://www.santacasasp.org.br/), 19
USP (University of São Paulo | http://www5.usp.br/), 24, 29, 33
Unesp (São Paulo State University | http://www.unesp.br/), 64
Vitoria, ES
UFES (Federal University of Espirito Santo | http://www.ufes.br/), 29

Bulgaria

Blagoevgrad
AUBG (American University in Bulgaria | http://www.aubg.edu/), 98
SWU (South-West University "Neofit Rilski" | http://www.swu.bg/), 60, 85, 193
Plovdiv
PU (Plovdiv University "Paisii Hilendarski" | https://uni-plovdiv.bg/), 24, 60, 85, 123, 130, 155, 184
UFT (University of Food Technologies-Plovdiv | http://uft-plovdiv.bg/), 130
Sofia
ASCI Ltd (ASCI Ltd | http://www.asci.bg/), 140
IE BAS (Academician Emil Djakov Institute of Electronics of the Bulgarian Academy of Sciences | http://www.ie-bas.org.bg/), 140, 160
IEES BAS (Institute of Electrochemistry and Energy Systems "Academic Evgeni Budevski" of the Bulgarian Academy of Sciences | http://iees.bas.bg/), 140
IMI BAS (Institute of Mathematics and Informatics of the Bulgarian Academy of Sciences | http://math.bas.bg/), 184
IMS BAS (Institute of Metal Science, Equipment end Technologies with Hydro- and Aerodynamics Centre "Acad. A.Balevsci" of the Bulgarian Academy of Sciences | http://ims.bas.bg/), 140
IMech BAS (Institute of Mechanics of the Bulgarian Academy of Sciences | http://www.imbm.bas.bg/), 24
INRNE BAS (Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences | http://www.inrne.bas.bg/), 13, 19, 24, 29, 33, 64, 84, 98, 101, 108, 114, 118, 123, 130, 140, 149, 175, 184, 192
ISSP BAS (Georgi Nadjakov Institute of Solid State Physics of the Bulgarian Academy of Sciences | http://www.issp.bas.bg/), 24, 84, 140
Inst. Microbiology BAS (Stephan Angeloff Institute of Microbiology of the Bulgarian Academy of Sciences | http://microbio.bas.bg/), 98, 153
LTD BAS (Laboratory for Technical Development of the Bulgarian Academy of Sciences | http://www.pronto.phys.bas.bg/), 85
NBU (New Bulgarian University | http://www.nbu.bg/), 19
NCRRP (National Centre of Radiobiology and Radiation Protection | http://ncrrp.org/), 160
NRA (Nuclear Regulatory Agency | http://www.bnra.bg/), 193
SU (Sofia University "St. Kliment Ohridski" | http://www.uni-sofia.bg/), 13, 24, 33, 41, 45, 60, 64, 98, 102, 104, 175, 184, 193
TU-Sofia (Technical University of Sofia | http://tu-sofia.bg/), 85
UCTM (University of Chemical Technology and Metallurgy | http://dl.uctm.edu/), 93

Canada

Corner Brook
MUN (Memorial University of Newfoundland - Grenfell Campus | http://www.grenfell.mun.ca/), 13
Edmonton
U of A (University of Alberta; Theoretical Physics Institute; Avadh Bhatia Physics Laboratory | http://www.ualberta.ca/), 29, 33, 184

France

Japan

Portugal

Republic of Korea

Chongju
- CBNU (Chungbuk National University | http://www.chungbuk.ac.kr/), 14, 65

Daegu
- KNU (Kyungpook National University | http://en.knu.ac.kr/), 14

Daejeon
- CTPCS IBS (Center for Theoretical Physics of Complex Systems of the Institute for Basic Science | http://www.ibs.re.kr/), 25
- IBS (Institute for Basic Science | http://www.ibs.re.kr/), 21
- KAERI (Korea Atomic Energy Research Institute | http://www.kaeri.re.kr:8080/), 131
- NFRI (National Fusion Research Institute | http://www.nfri.re.kr/), 131, 149

Gangneung
- GWNU (Gangneung-Wonju National University | http://www.gwnu.ac.kr/), 105

Kwangju
- CNU (Chonnam National University | http://www.jnu.ac.kr/), 65

Naju
- DU (Dongshin University; Laboratory for High Energy Physics | http://www.dsu.ac.kr/), 65

Namwon
- SU (Seonam University | http://www.seonam.ac.kr/), 65

Pohang
- PAL (Pohang Accelerator Laboratory | http://pal.postech.ac.kr/), 131

Seoul
- Dawonsys (Company "Dawonsys 'o., Ltd" | http: //www.dawonsys.co.kr/), 131
- EWU (Ewha Womans University | http: //www.ewha.ac.kr/), 52
- KU (Korea University | http://www.korea.ac.kr/), 65
- Konkuk Univ. (Konkuk University | http://www.kku.ac.kr/), 65
- SKKU (Sungkyunkwan University | http://www.skku.edu/), 30
- SNU (Seoul National University | http://www.snu.ac.kr/), 14, 21
- SNUE (Seoul National University of Education | http://www.snue.ac.kr/), 65

Romania

Baia Mare
- TUCN-NUCBM (Technical University of Cluj-Napoca - North University Center of Baia Mare | http://www.utcluj.ro/), 109, 131, 142, 156

Bucharest
- CNMN (National Centre for Micro and Nanomaterials of the University Politechnica of Bucharest | http://www.mocronanotech.ro/), 142
- CSSNT-UPB (Center for Surface Science and Nanotechnologe of the University Politehnica of Bucharest | http://cssnt-upb.ro/), 156
- IFA (Institute of Atomic Physics | http://www.ifa-mg.ro/), 176, 184
- IFIN-HH (Horia Hulubei National Institute of Physics and Nuclear Engineering | http://www.nipne.ro/), 21, 25, 34, 45, 48, 57, 60, 86, 98, 109, 115, 119, 123, 131, 142, 146, 156, 176, 184
- INCDIE ICPE-CA (National Institute of Research and Development in Electrical Engineering ICPE-CA | http://www.icpe-ca.ro/), 86, 93, 98, 131, 142, 149
- INFLPR (National Institute for Laser, Plasma and Radiation Physics | http://www.inflpr.ro/), 142, 156
- INOE2000 (National Institute for Research and Development in Optoelectronics | http://inoe.inoe.ro/), 86
- ISS (Institute for Space Sciences | http://www.spacescience.ro/), 52, 98, 105, 109, 131, 142, 169, 184
- NIMP (National Institute of Materials Physics | http://www.infim.ro/), 142
- N&V (http://www.nuclearvacuum.ro/), 115
- UB (University of Bucharest | http://www.unibuc.ro/), 21, 98, 123, 131, 142, 163, 166, 184, 193
- UMF (University of Medicine and Pharmacy "Carol Davila' - Bucharest' | http://www.umf.ro/), 109, 142, 160, 166
- UPB (University Politehnica of Bucharest | http://www.upb.ro/), 142, 156
- UTM (Titu Maiorescu University | http://www.utm.ro/), 142

Cluj-Napoca
- INCDTIM (National Institute for Research and Development of Isotopic and Molecular Technologies | http://www.itim-cj.ro/), 142, 176, 184
- RA BC-N (Romanian Academy Cluj-Napoca Branch | http://www.acad-cluj.ro/), 142
- UBB (Babeş-Bolyai University | http://www.ubbcluj.ro/), 142
- UTC-N (Technical University of Cluj-Napoca | http://utcluj.ro/), 25, 142

Constanţa
NIMRD (National Institute for Marine Research and Development "Grigore Antipa" | http://www.rmri.ro/), 131
UOC ("Ovidius" University of Constanta | http://www.univ-ovidius.ro/), 98, 131, 142
Craiova
UC (University of Craiova | http://www.ucv.ro/), 142
Galaţi
UG (University of Galaţi | http://www.ugal.ro/), 131
Iaşi
IBR (Institute of Biological Research Iaşi of the National Institute of Research and Development for Biological Sciences | http://www.dbioro.eu/), 160
NIRDTP (National Institute of Research and Development for Technical Physics | http://www.phys-iasi.ro/), 142
TUIASI ("Gheorghe Asachi" Technical University of Iaşi | http://www.tuiasi.ro/), 142
UAI (University "Apollonia" of Iaşi | http://univapollonia.ro/), 142
UAIC (Alexandru Ioan Cuza University of Iaşi | http://www.uaic.ro/), 132, 142, 160, 163
USAMV (University of Agricultural Sciences and Veterinary Medicine | http://www.uaiasi.ro/), 142
Oradea
UO (University of Oradea | http://www.uoradea.ro/), 132
Piteşti
ICN (Institute for Nuclear Research - Piteşti | http://www.nuclear.ro/), 132, 142
UPIT (University of Piteşti | http://www.upit.ro/), 142
Târgovişte
UVT (VALAHIA University of Târgovişte | http://www.valahia.ro/), 132, 142
Timişoara
ICT (Institute of Chemistry Timişoara of the Romanian Academy | http://acad-icht.tm.edu.ro/), 142
LMF CCTFA (Laboratory of Magnetic Fluids of the Center for Fundamental and Advanced Technical Research of the Romanian Academy, Branch Timişoara | http://acad-tim.tm.edu.ro/cctfa), 142
RA TB (Romanian Academy Timişoara Branch | http://acad-tim.tm.edu.ro/), 142
UPT (Politechnica University of Timişoara | http://www.upt.ro/), 142
UVT (West University of Timişoara | http://www.uvt.ro/), 25, 109, 142, 185
Tulcea
DDNI ("Danube Delta" National Institute for Research and Development | http://www.ddni.ro/), 142

Russia

Arkhangelsk
NArFU (Northern (Arctic) Federal University named after M.B.Lomonosov | http://narfu.ru/), 170, 193
NSMU (North State Medical University | http://www.nsmu.ru/), 193
Astrakhan
ASU (Astrakhan State University | http://asu.edu.ru/), 161
Belgorod
BelSU (Belgorod National Research State University | http://www.bsu.edu.ru/), 15, 25, 86, 143, 193
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/), 132
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/), 164
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/), 156
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Ukraine

United Kingdom