TOPICAL PLAN
FOR JINR RESEARCH
AND INTERNATIONAL COOPERATION
2020

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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, Radiation 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: In-progress

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 MPD/NICA program .

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

Expected results in the current year:

- Angular analysis of rare three-body B-meson's decays aimed for studying of the discovery potential for certain New Physics scenarios at modern and future B-factories.

  The calculation and the analysis of the structure of the high-order contributions to the RG quantities in SM extensions with additional scalars.

  Completion of the calculation of virtual corrections to the set of integrals over two-, three- and four-particle phase-space in massless QCD.

  Evaluation of two-point two-loop Feynman diagrams containing Elliptic structure in the form of Elliptic Polylogarithms.

  Evaluating a class of two-loop three-point functions, having inverse binomial form for the inverse mass expansions, in the terms of Goncharov polylogariths.

  Calculation of the three-loop corrections to the photon and fermion self-energy in the framework of the reduced Quantum Electrodynamics.

  Study of the critic behavior of 3-dimensional QED in the first three orders of $1/N_f$-expansion.

  Investigation of the Landau-Khalatnikov-Fradkin transformation in the case of the reduced Quantum Electrodynamics.

  Exploration of the semi-analytic approach for the transverse momentum dependent parton densities.

- Completion of the analysis of the phenomenological impact of radiative corrections to QCD Sum Rules for distribution amplitudes of (pseudo)scalar and (longitudinal and transverse) vector mesons and the corrections to the pion transition form factor at N^2LO.

  Study of the additional contributions of the oscillation terms of the scattering amplitude at different energies in the elastic proton-proton and proton-antiproton scattering.

  Lattice Investigations of hadron structure, more specifically spin content of nucleons and hyperons.

  Calculation of the transition form factors related to the pion-nucleon collision with producing the photon and nucleon and the nucleon gravitational form factor C(t) within the Light-Cone Sum Rules approach including NLO(QCD)-term and all twist contributions.

  Determination of the polarized parton distribution functions and fragmentation functions in hadrons incorporating transverse momentum of the quarks (Boer-Mulders, Sivers, Collins) with the use of the experimental data on the difference cross sections and asymmetries in SIDIS

  Study of Z(N) symmetry and thermodynamic properties of meta-stable states at very high temperature relevant to Heavy-Ion Collision and Early Universe Cosmology.

  Calculation of quark-gluon contributions to exclusive Drell-Yan process for different traetments of imaginary phases.

- Development of tools for calculation of three-loop quark diagrams describing the W-exchange contri-bution to the nonleptonic two-body decays of the single- and doubly charmed baryons.

  Calculation of branching ratios of the decays accessible experimentally and comparison of the tree level and W-exchange contributions.

  Study of the exotic Y(4260) meson as a four-quark state having molecular structure and calculation of its strong decays.

  Investigation of the properties of scalar, axial-vector and tensor mesons, dominant radiative transitions of excited charmonium states and calculation of their decay widths in the framework of quark models with analytical confinement.

  Investigation of the properties of dense hadron matter, calculation of the mass spectrum, decay con-stants and analysis of the dynamics of exotic hadrons and heavy glueballs.

  Analysis and theoretical studies of new experimental data (at CERN, GSI, BES-III) for heavy baryon decays.

  Calculation of one and two loop diagrams of self-energy for a bound Dirac electron in the two-center problem in the Furry representation without expansion in terms of the strength of the binding energy .

  Calculation of parameters of the hyperfine splitting of the spectral lines of the pure rotational transition in the molecular ion HD+ in order Z^6. That will allow to improve atomic masses of deuteron and proton from comparison with experiment and to achieve a new level of relative precision of 10^{-11} in testing quantum electrodynamics in the three-body sector, which is one order of magnitude better than from the previous results.

- Study phase transitions in quark matter at zero temperature and nonzero isospin density.

  Study of the phenomenon of string breaking in dense quark matter in QCD-like theories.

  Investigation of Confinement/deconfinement phase transition is gluon plasma. In particular, study of nonzero angular velocity influence on the confinement/deconfinement critical temperature, properties of the system above deconfinement.

  Investigation of transport properties of quark-gluon plasma at nonzero density by means of QCD lattice simulations at imaginary chemical potential and analytically continuation of calculated transport coefficients to real chemical potential.

  Study of statistical and thermodynamical properties of dense hadronic matter within the domain model of QCD vacuum, in various regimes of hadronic, mixed and quark-gluon phases.

  Fluctuations of particle number, charge and charged-to-neutral particle ratio in a pion-enriched gas will be studied in grand canonical and canonical ensembles including finite-size effects and particle interactions.

The results will be applied to the description of the nuclear systems produced in heavy-ion collisions at RHIC and LHC energies.

Application of non-extensive statistics to description of relativistic heavy ion collisions.

The PHSD model will be extended to include mean-field potentials acting on fermions and bosons. This will allow for a quantitive comparison of various relativistic mean-field models in application to heavy-ion collisions.

Particle flow pattern (directed flow) and vorticity of a medium produced in nucleus collisions at NICA energies will be investigated within the three-fluid hydrodynamics approach. The problems of initial thermalization and light fragment production at NICA energies will be considered.

Development of a unified quark-hadron equation of state fulfilling constraints from Lattice QCD thermodynamics and compact star astrophysics. Extraction of properties of the low-temperature, high-density equation of state from phenomenology of compact stars, their mergers and supernova explosions; implications for the existence of a critical endpoint in the QCD phase diagram.

- Systematic study of the low-energy meson dynamics in tau lepton decays within effective models of strong interactions.

  Elaboration of contributions to the physical programs of future collider experiments including the Super Charm-Tau Factory and the FCCee projects.

  Development of new techniques for evaluation of polarized and unpolarized nucleon structure and fragmentation functions and applications to the experimental data analysis.

  Application of effective low-energy QCD models to describe the equation of state of hadronic matter in compact stars.

  A theoretical analysis of the forthcoming experimental data on the muon anomalous magnetic moment.

  Further development of the Monte-Carlo neutrino generator GENIE, release 3: incorporation of a superscaling model SuSAM* for neutrino-nucleus interactions at intermediate energies and of an extended model for resonance pion neutrinoproduction on nucleons and nuclei; detailed statistical analysis of the modern accelerator data on neutrino-nucleus interactions;for tuning the generator;writing the user manual.

  Development of the theory of neutrino propagation through an inhomogeneous matter which includes the mixing with sterile neutrinos and takes into account neutrino absorption and refraction. Development of a C++ code for analysis of data from the Baikal megaton neutrino telescope GVD.

  Further work within the international collaboration NOvA. Analysis of the data from near neutrino detector using the so-called "JINR model" for neutrino-nucleus interactions. Incorporation of the newest releases of the GENIE package into the NOvA software.

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 Berlin
	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	Meiji Univ.
		Tokyo Tech
		UT
	Kyoto	Kyoto Univ.
	Nagoya	Nagoya Univ.
	Tsukuba	KEK
Kazakhstan	Nur-Sultan	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
	Wroclaw	ITP UW
Portugal	Coimbra	UC
Republic of Korea	Seoul	SNU
	Daegu	KNU
	Cheongju	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
	Dnipro	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: In-progress

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, United Kingdom, 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 results in the current year:

- Investigation of the nature of vortical states in nuclei within the random-phase-approximation method with Skyrme forces.

  Study of the relationship between collective and cluster motions in light nuclei within the proton-neutron symplectic shell-model theory.

  Study of the effect of the phonon-phonon coupling on the E0- strength distribution in the neutron-rich Sn isotopes.

  Study of the pygmy dipole resonance of ^{134}Sn via the beta-decay of the nucleus ^{134}In.

  Study of low lying 1^+ and 2^+ excitations in nuclei by solving the Hartree-Fock-Bogoliubov equations with the method of Wigner function moments for the harmonic oscillator model with quadrupole and spin-quadrupole interactions.

  Investigation of the effect of the coupling between one- and two-phonon configurations in hot nuclei on the rates of weak- interaction mediated process in supernova matter.

- Analysis of the production cross sections of superheavy nuclei with the self-consistent mean-field model and predictions of their properties.

  Analysis of the production of new isotopes in multinucleon transfer reactions.

  Evaluation of the excitation functions in the reactions of astrophysical interest.

  Study of the influence of the mass/charge ratio in colliding nuclei on the capture and complete fusion probabilities in reactions with the same total number of protons in the projectile and target.

  Investigation of the level densities in the ground states and at the barrier in superheavy nuclei.

  Study of the influence of coupled nucleon and alpha particle transitions between nuclei in the dinuclear system on fusion-fission probability.

  Study of equilibration and thermalization in finite quantum systems embedded into few heat bathes and external fields.

  Exploration of 6He strength functions for transitions to different Gamow-Teller channels, including the beta decay into the two-body 4He+d channel which until now has no satisfactory explanation.

- Quantum-mechanical analysis of atom-ion confinement-induced resonances, including the effect of ion motion.

  Low-energy approximation of the two-dimensional scattering amplitude by a superposition of Coulomb and decreasing power-like potentials.

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

  Construction of the adiabatic theory of ultra-narrow autoionization resonances of the helium atom.

  Investigation of scattering processes in the system of three beryllium atoms with realistic pairwise interactions in collinear configuration.

  Study of the Efimov resonances in asymmetric three-atom systems.

  Study of the energy exchange in neutrino scattering by nuclear particles.

  Study of angular and energy spectra of Compton scattering of photons on the bound electrons of atoms and molecules.

  Study of cluster states in 1p shell nuclei.

- Systematic study of nonlinear quantum processes in strong electromagnetic fields is planned, in particular, investigation of multi-photon regime of quantum processes with short ultra-short intensive laser pulses with different pulse polarization.

  Development of theoretical models for production of exotic hadrons in photo- and hadron- induced reactions as a probe for the reaction mechanism and structure of exotic hadrons.

  Obtaining pf the amplitude of the process $\pi\pi \to \pi\pi$ using a separable model; derivation of the equation of state for baryon matter in the frame of the SU(3) PNJL model; study of the chiral phase transition of quark matter under rotation in the Nambu-Jona-Lasinio (NJL) model.

  Analytical continuation of the numerical solution of the Dayson-Scwinger equations (the rainbow approximation) to Euclidean space of complex momenta and detailed analyses with the aim of subsequent implementation in the Bethe-Salpeter equations for two-gluon bound states.

  Obtaining of the transverse momentum distributions of hadrons created in high-energy heavy-ion and proton-proton collisions in the Tsallis nonextensive statistics and the local equilibrium statistical models.

  Theoretical analysis of the one proton halo nucleus 17F scattering on nuclei by using the developed microscopic model of optical potential.

  Investigation of the influence of event-by-event fluctuations on pion and proton rapidity distributions and transverse momentum spectra for NICA energies within the HydHSD hybrid model.

  Investigation of elastic and inelastic electron-deuteron scattering in the Bete-Salpeter approach with large momenta transfer.

  Investigation of the ^{3}He electromagnetic form factors and elastic nucleon-deuteron scattering in the Bethe-Salpeter-Faddeev relativistic formalism using multirank separable kernels.

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, V.G. Kartavenko, Sh. Kalandarov, A.K. Nasirov, R.G. Nazmitdinov, H. Paşca, P. Wen, A. Rahmatinejev, 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, O.P. Klimenko, E.A. Kolganova, V.N. Kondratyev, A.A. Korobitsyn, E.A. Koval, A.V. Malykh, V.S. Melezhik, 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	BRC 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
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
	Omsk	OmSU
	Saratov	SSU
	St. Petersburg	SPbSU
	Vladivostok	FEFU
Serbia	Belgrade	IPB
Slovakia	Bratislava	CU
		IP SAS
South Africa	Pretoria	UNISA
	Stellenbosch	SU
	Faure	iThemba LABS
Spain	Palma	UIB
Sweden	Lund	LU
	Göteborg	Chalmers
Switzerland	Bern	Uni Bern
Taiwan	Taipei	NTU
		IP AS
United Kingdom	Guildford	Univ.
Ukraine	Kiev	BITP NASU
		KINR NASU
		NUK
	Kharkov	NSC KIPT
USA	Lemont, IL	ANL
	Raleigh, 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
	Namangan	NamETI

01–3–1137–2019/2023	Priority: 1

Status: In-progress

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 results in the current year:

- Studying of superconductivity in the t-J Kitaev model and calculation of the superconducting transition temperature for various parameters of the model.

  Calculation of the dc conductivity in the electron-doped cuprate and comparison of the results with experiments performed at the NIC “Kurchatov Institute”.

  Studying of the relationship between the exchange coupling of rare-earth terbium ions, the electronic and lattice structures of metallic terbium varying under the strong external pressure and comparison of results with experimental data obtained at FLNP, JINR.

  Analysis of magnetic interactions between spin-orbit-coupled j=1/2 moments forming structural chains in iridium and rhodium oxides with face-sharing octahedral arrangement.

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

  Investigation of physical properties of smart polymeric membranes for technical and bio-medical applications.

  Investigation of the properties of optical lattices under the increase of intersite interactions.

  Development of a method for an efficient regulation of polarization in ferroelectrics.

  Calculation of the neutron scattering spectra for a structure of a kagome-strip geometry recently observed in A2Cu5(TeO3)(SO4)3(OH)4 (A=Na, K) for the purpose of a possible experiment proposal for IBR-2. Calculation and comparison of the spin-wave spectrum on such a lattice with the results of possible neutron scattering experiment.

- Development of a microscopic theory to describe the experimentally observed transition to the charge density wave phase in the underdoped cuprates.

  Investigation of the transport and optical properties of new two-dimensional materials taking into account the effects of disorder.

Investigation of the influence of boundary states and various types of defects on the electronic density of states, electron conductivity and mobility in the monolayer molybdenum disulfide using the real-space Green-Kubo formalism and the non-equilibrium Green function methods.

Study of electron properties of interfaces, such as graphene-fluorographene and graphene-molybdenum disulfide monolayer. Calculation of both the local DOS on the interfaces of structures and the conductance.

Investigation of the electron mobility and conductivity in polycrystalline graphene.

Study of transport properties of Weyl type II semimetal junctions with unconventional superconductors.

Investigation of resonance, chaotic and topological features in Josephson nanostructures with magnetic layers.

Investigation of the possibility of synchronization of the magnetic moments dynamics in a one-dimensional array of nanomagnets coupled to the Josephson junction.

Study of the properties of the electromagnetic pulses propagating through a one dimensional structure consisting of optically active quantum two-level systems.

- Description of the limit shapes and universal fluctuations of multi-polymer configurations in the model of uniform and weighted spanning forests on the lattice.

  Construction of stationary states in the model of interacting particles with generalized exclusion on the segment with open boundary conditions.

  Description of interfaces in the dimer models with alternating weights at the bounded domains of planar lattices and characterization of the dependence of their statistics on the shape of the domain.

  Obtaining of exact asymptotic expansions of free energy and phase diagrams for dimers on lattices with different geometry and different boundary conditions.

  Construction of the Gauss decomposition for the matrix of generators of the Reflection Equation (RE) algebra by means of the spectral extension of the RE-algebra.

  Construction of the hyperbolic hypergeometric function connected to the general lens space and investigation of its symmetries, the equation it satisfies and its limiting cases. Investigation of the elliptic analogues of these functions related to superconformal indices of four dimensional field theories.

List of activities:

Activity or experiment **Laboratory or other Division of JINR**	**Leaders** **Main researchers**
1. **Complex materials**	**E. Anitas** **N.M. Plakida**
BLTP	A.Yu. Cherny, A.A. Donkov, A.L. Kuzemsky, Tung Nguen Dan, A.A. Vladimirov, V.I. Yukalov, V.Yu. Yushankhai
FLNP	V.L. Aksenov, A.M. Balagurov, A. Islamov, D.P. Kozlenko, A.I. Kuklin, E.P. Popov
LIT	L.A. Syurakshina, E.P. Yukalova
2. **Nanostructures and nanomaterials**	**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, I.R. Rahmonov, O.G. Sadykova, Yu.M. Shukrinov
LIT	I. Sarhadov, S.I. Serdyukova, E.B. Zemlianaya
LRB	A.N. Bugay
LNR	A. Olejniczak

3. **Mathematical models of statistical physics of complex systems** — **A.M. Povolotsky**

BLTP — A.E. Derbyshev, V.I. Inozemtsev, 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
		JIPNR-Sosny NASB
		SPMRC NASB
		UCP MES
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
	Olomouc	UP
Denmark	Lyngby	DTU
Egypt	Giza	CU
France	Annecy-le-Vieux	LAPTh
	Paris	UPMC
	Marseille	CPT
		UPC
	Nice	UN
	Valenciennes	UVHC

Germany	Bremen	Univ.
	Braunschweig	TU
	Dortmund	TU Dortmund
	Darmstadt	GSI
		TU Darmstadt
	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
Italy	Catania	UniCT
	Fisciano	UNISA
Japan	Utsunomiya	UU
Mongolia	Ulaanbaatar	NUM
		IPT MAS
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
		ITMO Univ.
		PDMI RAS
		SPbSU
	Vladimir	VlSU
	Voronezh	VSU
Serbia	Belgrade	INS “VINČA”
Slovakia	Bratislava	CU
	Košice	IEP SAS
		UPJS
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: In-progress

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 results in the current year:

- Construction of renormalization group flows on curved manifolds via the holographic duality. Studies of phase diagrams using the obtained holographic RG flows.

  Calculation and study of thermal correlators corresponding to quantum KdV charges in 2d CFT. Construction of the full KdV partition function in the case of free bosons.

  Construction of holographic RG flows with several effective charges. Consideration of these RG flows in terms of brane intersections in a relevant supergravity theory. Studies of the RG flows in the framework of the generalized Sachdev-Ye-Kitaev model.

  Development of a group-theoretical approach for the twistor description of massless particles with a continuous spin. The comparison of this approach with the Penrose twistor program.

  Construction of projectors for the irreducible representations of the multidimensional Poincare group (for an arbitrary type of symmetry) based on the results from the representation theory of the Brauer algebra and the methods of the R-matrices (the solutions of the Yang-Baxter equation, which are constructed in terms of the Brauer algebra generators).

  Study of the systems with partially broken supersymmetry, with an arbitrarily high number of spontaneously broken supersymmetries, in particular, systems of many N=1, d=3 scalar and vector multiplets, as well as their analogues in higher dimensions.

Construction of non-symmetric eigenfunctions of the deformed Macdonald–Ruijsenaars systems in terms of the representation theory of the Ding–Iohara algebra and, in the explicit form, calculation of eigenvalues for these eigenfunctions. Construction of quantum Lax pairs for the deformed Calogero–Moser systems (rational, trigonometric, elliptic) by means of the Dunkl operators. Construction of symmetries of the elliptic Gaudin model by means of the quantum spectral curve. Generalization of Manin matrices.

Construction of monotonic lagrangian tori of non-standard type in toric and pseudotoric Fano manifolds in the framework of Mirror Symmetry. Construction of examples of non-standard lagrangian tori which have non-trivial Maslov classes and, therefore, do not admit hamiltonian deformations to the minimal ones.

Construction of the trigonometric and hyperbolic Calogero models with extended supersymmetry.

- Continuing the study of the quantum structure of N=(1,0), N=(1,1) and N=(2,0) supersymmetric gauge theories in 6 dimensions by the harmonic superspace methods, constructing the superfield invariants and effective action of these theories, further revealing of their relationships with the AdS/CFT correspondence. Analogous superfield analysis of N=(1,0) and N=(1,1) gauge theories with higher-derivatives. Study of the quantum superfield geometry of N=2, 5D super Yang-Mills theory, finding out the relation of the relevant effective action with the D4 brane action.

  Investigations of multiparticle Calogero-type systems with extended Poincare and superconformal supersymmetries, construction of their various SU(m|n) deformations on the basis of the superfield gauging of matrix models. Construction of quantum versions of the hyperbolic and trigonometric supersymmetric Calogero-Sutherland models, analysis of their possible integrability. Building new mechanics models with extended supersymmetry on curved spaces, analysis of their quantum properties, as well as the issues of their integrability and relationship with the matrix models of string theory. Study of the question of possible uses of the models constructed in nuclear physics and high-energy particle physics.

  Generalization, to the complex, quaternionic and projective spaces, of the known superintegrable oscillator-like systems allowing the inclusion of the constant magnetic/instanton external field, and further supersymmetrization of these generalized systems. Construction and study of the superintegrable versions of the oscillator models with extra Calogero-like potentials on complex/quaternion projective spaces, in interaction with the external constant magnetic/instanton fields, "weak"N=4 and N=8 supersymmetrization of such systems, finding out their superfield formulations. Construction of hyper-Kahler and quaternionic analogs of the Smorodinsky-Winternitz and Rosokhatius systems, as well as of their “weak” N=4 and N=8 supersymmetric extensions, analysis of their symmetries and finding their classical and quantum-mechanical solutions. Generalization to the Calogero-type systems.

  Construction of twistor formulations of particles and superparticles with a continuous spin (helicity), as well as their quantization in the component and superfield approaches.

  Further investigations of the properties of topological solitons in classical and quantum field theory in flat and curved space-time. Analogous analysis of the black hole solutions, as well as the localized field-configuration solutions in various versions of the gravitation theory coupled to the matter fields, including non-abelian gauge fields.

  Analysis of the quasi-classical limits of the three-point functions in the Liouville theory and its super-extensions. Study of the light and heavy asymptotic limits in these theories. Clearing up the properties of the fusion matrix based upon the analysis of these limits, as well as of the relationship between the boundary three-point function and the fusion matrix. Study of the boundary three-point function in the heavy limit and its computing proceeding from the boundary Liouville theory defined on the solutions with three boundary singularities. Exhibiting the information about the monodromy of the solutions of the equations of Goin and Painleve VI by means of using the relationship of the conformal blocks with the solutions of these equations in the heavy asymptotic limits.

- Study of algebra-geometric structures related with the full symmetric Toda system based on the representation theory, inverse scattering method and other modern methods of studying integrable systems. Explanation of the full Toda system's integrability in terms of the Lie-algebraic approach, search for the reason for the existence of large (commutative and noncommutative) families of integrals of this system. Search for a general principle, behind the Bruhat order emerging in the phase portrait of this system, as well as search for its analogs in the infinite-dimensional limits of the system (the KdV system) and

providing a complete description of the integrands in the case of degenerate orbits of the Toda system, in particular on RP(n).

Study of stationary (black holes, black hole systems) and cosmological solutions (inflation, dark energy) in Einstein and modified gravitations of the Horndeski type and others. Study of the prospects for the application of the Palatiny formalism, which is characterized by a smaller number of singularities, in the construction of realistic cosmological models.

Investigation of a subclass of the Stephani models with ideal gas and a matter-radiation mixture. Generalization of the model to the case with nonzero cosmological constant and calculation of observable parameters. Calculation of the probability for a black hole formation in the early universe at the dust stage from the growing density contrasts of the scalar inflaton field.

Investigation of the vacuum energy in the boundary vicinity for CFTs. Computation of the entanglement entropy and pursuing the relation between the entropy and the geometry of the manifold and its boundary.

The aim of the forthcoming research is to obtain new constraints on the parameters of black holes and neutron stars from the observational data acquired in 2019 by the Event Horizon Telescope and other observational facilities, as well as restrictions on the alternative theories of gravity.

Investigation of the cosmological perturbations in covariant formulation of teleparallel gravity. Derivation of equations for scalar perturbations within this approach and obtaining the spectrum of scalar perturbations during inflation.

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

		Foundation ANSL
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
	Montreal	Concordia
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
		IACS
	Chennai	IMSc
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	Bialystok	UwB
	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, MA	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: In-progress

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 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	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
	Fisciano	UNISA
	Trieste	SISSA/ISAS
	Turin	Uni'To
Japan	Kyoto	KSU
		RIMS
	Tsukuba	KEK
	Chiba	CIT
Norway	Oslo	UiO
Poland	Warsaw	UW
	Wroclaw	UW
Romania	Bucharest	IFIN-HH
Russia	Moscow	ITEP
		LPI RAS
		NRU HSE
		MSU
		SCC RAS
		SINP MSU
		MI RAS
		VNIIMS
	Moscow, Troitsk	INR RAS
	Chernogolovka	LITP RAS
	Protvino	IHEP
	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.
	Southampton	Univ.
	York	Univ.
USA	New York, NY	CUNY
		SUNY
	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)

02–2–1123–2015/2022	Priority: 1

Status: Extended

Study of Fundamental Interactions in e^+e^- Collisions

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 Standard Model (SM) provides the most accurate and universal description of the physics phenomena on a microscale nowadays. However, it is not free from a number of shortcomings. Some predictions of the Standard Model still have not been observed experimentally. In many cases the accuracy of the predictions is limited by the experimental knowledge of the key free parameters of the theory. At the same time, the search for New Physics beyond the Standard Model may show the way to further develop the theory and to get rid of its shortcomings. The main tool for these studies is the collider experiments using both proton-proton (LHC) and electron-positron collisions. The latter are most suitable for the precision studies of elementary particles with obvious advantages from well-defined kinematics of the initial state and the absence of the large QCD background typical of hadronic colliders.
Precision test of SM predictions and search for new phenomena beyond the SM in charmonium and tau lepton decays are fulfilled in the scope of this theme using the world best facility in this energy domain - the unique electron-positron collider BEPC-II and the BES-III detector. At the same time, preparation for experiments at the future electron-positron colliders (ILC, CLIC, CEPC, FCC-ee) is under way.

Expected results in the current year:

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

List of projects:

	Project	Leader	Priority (period of realization)
1.	BES-III	A.S. Zhemchugov	2 (2007 – 2022)
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, Yu.A. Nefedov, G.A. Shelkov	
BLTP	V.V. Bytev	
LIT	V.V. Korenkov, G.A. Ososkov, I.S. Pelevanyuk	
2. **ARIeL Project**	**L.V. Kalinovskaya**	Realization
DLNP	I.R. Boyko, E.V. Dydyshko,Yu.A. Nefedov, N.E. Pukhaeva, S.S. Rzaeva, L.A. Rumyantsev, A. Rymbekova, A.A. Sapronov, R.R. Sadykov, P.V. Shvydkin, A.S. Zhemchugov, V. Yermolchyk	
BLTP	A.B. Arbuzov, C.G. Bondarenko	
LIT	I.S. Pelevanyuk	

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Belarus	Minsk	INP BSU
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

02–0–1081–2009/2024	Priority: 1

Status: Extended

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:

Absolutely new and unique data will be obtained in multifaceted and comprehensive researches of proton-proton scattering processes. Analysis of these data will allow several fundamental physical problems to be solved. Within this project, JINR scientists will participate in these analyses.
It is expected to obtain new results and make publications on all above-mentioned tasks where JINR scientists have responsibilities. The most important tasks are the studies of the proton structure and hadron state spectrum, probing of the Standard Model at the LHC energies, search for and investigation of supersymmetry, search for the evidence of existence of new particles and new interactions. In addition JINR intend to obtain new results that will help specify properties of already known elementary particles such as $W-$ and $Z-$bosons, top-quark, heavy barions etc.
Implementation of this Project aimed at solving highly significant scientific problems unique applied results that may significantly change the quality of life. Among these results can be experience in operation of remote monitoring systems for technically complicated apparatus, longterm development and use of distributed comtputing systems, etc.

Expected results in the current year:

- Investigation of the applicability of the Standard Model and verification of SM predictions (including interactions of heavy ions), determination the structure of the proton at ultra-high energies (PDFs), tuning and improvement of relevant computer codes and events generators etc.
- Search for the chiral Z^*/W^* bosons in the two-jet decays and in the process with more complex topology of their associative production including heavy b and t quarks.
- Search for (supersymmetric) charged Higgs bosons via their specific decay modes (3-lepton, etc).
- Analyses on associated productions of the SM Higgs withpair and search for production with single top.
- Search for a valence-like nonperturbative component of heavy quarks in the proton (intrinsic heavy quarks) via specific final state topology in the pp interactions.
- Search for new hadrons and baryons containing heavy c and b quarks and study of their properties.
- Measurement of the Drell Yan triple-differential cross section and effective leptonic weak mixing angle in the Z-boson decay.
- New comprehensive study of the gluon structure of the proton, etc.
- Search for quantum black holes in the lepton+jet channel at 13 TeV.
- Participation in the development event trigger indexing infrastructure.
- Development and maintenance of the TDAQ system.

List of projects:

Project	Leader	Priority (period of realization)
1. ATLAS. Physical researches at LHC	V.A. Bednyakov Deputies: E.V. Khramov A.P. Cheplakov	1 (2010 – 2023)
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 Yu.A. Budagov N.A. Russakovich G.P. Chelkov	A.M. Artikov, N.V. Atanov, V.Yu. Baranov, V.Yu. Batusov, I.R. Boyko, M.V. Chizhov, Z. Chubinidze, Yu.I. Davydov, D.V. Dedovich, M.A. Demichev, A.V. Ershova, V.A. Gerasimov, L.R. Gladilin, V.V. Glagolev, A. Gongadze, I. Gongadze, L. Gongadze, M.I. Gostkin, A.V. Guskov, N. Huseinov, Yu.P. Ivanov, L.V. Kalinovskaja, S.N. Karpov, Z.M. Karpova, D.V. Kharchenko, I. Kostyukhina, O.A. Koval, D.A. Kozhevnikov, V.G. Kruchonok, Yu.A. Kultchitsky, M.V. Lyablin, G.I. Lykasov, V.V. Lyubushkin, T.V. Lyubushkina, S.N. Malyukov, M. Manashova, I. Minashvili, I. Minashvili I., Yu.A. Nefedov, A.A. Nozdrin, E.M. Plontikova, S.Yu. Porokhovoy, I.N. Potrap, F.V. Prokoshin, V.M. Romanov, T.O. Rudenko, S.S. Rzaeva, R.R. Sadykov, A.A. Sapronov, A.V. Simonenko, P.I. Smolyanskiy, M.M. Shiyakova, A.N. Shalyugin, Yu.Yu Stepanenko, V.V. Tereschenko, I.N. Troeglazov, P.V. Tereshko, S.M. Turchikhin, Yu.A. Usov, Z. Usubov, A.O. Vasyukov, I.V. Yeletskikh, A.S. Zhemchugov	
VBLHEP A.P. Cheplakov	F.N. Ahmadov, Yu.A. Fillipov, A.V. Ivanov, N.A. Javadov, V.V. Kukhtin, E.A. Ladygin, S.N. Nagorny, A.A. Soloshenko, N.I. Zimin, B.G. Shaykhatdenov, T. Turtuvshin	
LIT V.V. Korenkov, P.V. Zrelov	E.A. Alexandrov, I.N. Aleksandrov, N.I. Gromova, A.V. Iakovlev, A.I. Kazymov, M.A. Mineev, D.A. Oleinik, A.Sh. Petrosyan, V.N. Shigaev	
BLTP D.I. Kazakov	A.B. Arbuzov, A.V Bednyakov, S.G. Bondarenko, A.V. Gladyshev, A.F. Pikelner, O.V. Teryaev	
FLNP S.A. Kulikov	M.V. Bulavin	

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	IAP NASB
		INP BSU
		IP NASB
		JIPNR-Sosny 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	ITEP
		LPI RAS
		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: Being concluded

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 a high precision. The comparison between experiment and the SM 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. The 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 the MEG II experiment at PSI are a dedicated search for the CLFV processes $\mu^- N \rightarrow e^- N$, $\mu^+ \rightarrow e^+ \gamma$. Once neutrinos masses are included, the process is allowed but still effectively 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 ith and jth neutrino mass eigenstates, and M_W is the mass of the W boson. The predicted rates for the $\mu^- N \rightarrow e^- N$ and $\mu^+ \rightarrow e^+ \gamma$ CLFV processes are less than 10^{-50} each. This makes this process a very theoretically clean place to search for NP effects. In many NP models that include a description of neutrino mass, the rates for these processes are enormously enhanced so that they occur at a level to which Mu2e experiment will have sensitivity.

Participation in the creation and tests of the theoretical views in the topics. Study of CP-violation in the lepton sector with the help of neutrinos. 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 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 with the gamma sources and electron beam.
- Participation in the construction and tests of modules of scintillator counters for the veto system. Quality control.
- Maintenance of the final version of the visualization and control software.
- Development and tests of the Mu2e e.m. calorimeter preamplifiers at JINR.
- 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 the development of the positron tracker for the MEG-II experiment, DAQ, data analysis.

- Participation in the data taking and analysis of experimental data obtained with 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.
- Data analysis of the $p + t$ synthesis using the muon catalysis method.

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, I.K. Zimin	
	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.V. 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	Frascati	INFN LNF
	Pisa	UniPi
Russia	Moscow, Troitsk	INR RAS
	Gatchina	NRC KI PNPI
Romania	Bucharest	IFIN-HH
Slovakia	Bratislava	CU
		IP SAS
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: In-progress

Study of Neutrino Oscillations

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

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

Expected results in the current year:

- Physics analysis of the Daya Bay experiment data on θ_{13} determination.
- Precision estimation of the mass hierarchy measurements and determination of neutrino oscillation parameters in the NOvA and JUNO experiments by different methods.
- Data analysis in the NOvA experiment.
- Study of systematic uncertainties related to the neutrino-nucleon cross sections for the NOvA analysis.
- Use of NOvA experiment Remote Operation Centre at JINR for shifts.
- Start of the mass production of the high voltage system for JUNO PMTs.
- Mass test of JUNO PMT with scanning stations.
- Monitoring of the JUNO veto system planes.
- Reconstruction of events in the Borexino detector.
- Analysis of SNO solar neutrino parameters in the Borexino detector.

List of projects:

	Project	Leader	Priority (period of realization)
1.	Daya Bay/JUNO	D.V. Naumov	1 (2009 – 2020)
2.	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. **Daya Bay/JUNO Project**	**D.V. Naumov** **M.O. Gonchar**	Data taking R&D
DLNP	V.V. Amvrosov, N.V. Anfimov, T.A. Antoshkina, S.V. Biktemerova, A.E. Bolshakova, I.V. Butorov, A.V. Chukanov, S.G. Dmitrievsky, D.A. Dolzhikov, 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	
2. **NOvA Project**	**A.G. Olshevskiy** **O.B. Samoylov**	Data taking
DLNP	V.A. Allakgverdian, A.I. Antoshkin, N.V. Anfimov, A.I. Kalitkina, O.A. Klimov, Ch. Kullenberg, L.D. Kolupaeva, A.D. Morozova, O.N Petrova, M.V. Petropavlova, 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	
3. **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	
4. **Experiment Borexino/DarkSide**	**O.Yu. Smirnov**	Data analysis
DLNP	M.V. Gromov, D.V. Korablev, O.B. Samoylov, A.P. Sotnikov, A.S. Sheshukov, A.V. Vishneva	
5. **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. Sokolov	
VBLHEP	Z.Ya. Sadygov	

Collaboration

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

02–0–1108–2011/2020	Priority: 1

Status: Extended

PANDA Experiment at FAIR

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

Participating countries and international organizations:

Belarus, CERN, Germany, Russia.

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 results in the current year:

- Readiness of the MDT detector design for mass production.
- Signing of the FAIR-JINR contract on the Muon System construction.
- Start of the construction of the detector production facility.
- Study of exotic multiquark states and flavor hadrons, simulations of production and decay processes, preparation of publications.

List of activities:

Activity or experiment Laboratory or other Division of JINR Responsible person	Leaders Main researchers	Status
1. **Experiment PANDA**	**G.D. Alexeev**	Technical proposal
DLNP A.N. Skachkova	V.M. Abazov, G.A. Golovanov, G.I. Lykasov, V.L. Malyshev, A.A. Piskun, D.V. Pontecorvo, I.K. Prokhorov, A.M. Rozhdestvensky, A.G. Samartsev, N.V. Skachkov, V.V. Tokmenin, V.P. Volnykh, A.Yu. Verkheev, N.I. Zhuravlev	
VBLHEP A.S. Vodopyanov	V.A. Arefev, V.I. Astakhov, M.Yu. Barabanov, B.V. Batyunya, v.A. Budilov, A.S. Galoyan, V.K. Dodokhov, A.A. Feshchenko, E.K. Koshurnikov, D.I. Krestnikov, V.I. Lobanov, Yu.Yu. Lobanov, P.V. Nomokonov, V.N. Roinishvili, E.A. Strokovsky, S.S. Shimansky, A.O. Sidorin	
LIT	V.V. Uzhinsky	
BLTP	A.V. Efremov, A.S. Sorin, O.V. Teryaev	

Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	IP NASB
CERN	Geneva	CERN
Germany	Darmstadt	GSI
Russia	Protvino	IHEP
	Novosibirsk	BINP SB RAS
	Omsk	OB IM SB RAS

02–2–1125–2015/2020	Priority: 1

Status: Being concluded

Astrophysical Studies in the TAIGA Experiment

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 topics of multi-messenger TAIGA array are gamma-ray astronomy, charged cosmic ray physics and particle physics. Gamma-ray astronomy: one of the most intriguing problems in high-energy astroparticle physics is a search for galactic objects for accelerating of particles up to PeV energies (the so-called Pevatrons); VHE spectra of the known sources: where do they stop; absorption in IR and CMB; diffuse emission from the galactic plane and the 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 was 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 and 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 study using 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 the 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 CR spectrum and composition are known from direct observations with detectors placed in balloons and earth satellites. However, at higher energies the CR flux is smaller and more difficult for direct 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 results in the current year:

- Design and production of the third IACT for the TAIGA experiment.
- Participation in the of TAIGA experiment data taking.
- Participation in the MC simulation of the TAIGA experiment and data analysis.
- Participation in the TUS data analysis.
- Participation in the NUCLEON data analysis.

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, 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, 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. Śadovsky, I. Satyshev, 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	Hamburg	Univ.
	Munich	MPI-P
	Tübingen	Univ.
	Zeuthen	DESY
Italy	Turin	UniTo
Japan	Wako	RIKEN
Mexico	Puebla	BUAP
Poland	Warsaw	UW
Republic of Korea	Seoul	EWU
Romania	Magurele	ISS

Russia	Moscow	NNRU “MEPhI”
		SINP MSU
	Moscow, Troitsk	INR RAS
	Irkutsk	RIAP ISU

02–2–1134–2018/2020	Priority: 1

Status: Extended

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

Expected results in the current year:

- R&D of thin-wall straw tubes for COMET. Development, production and tests of the straw detector and electromagnetic calorimeter prototype.
- Calibration of LYSO crystals.

List of activities:

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

Collaboration

Country or International Organization	**City**	**Institute or Laboratory**
Belarus	Minsk	BSU
		IP NASB
Czech Republic	Prague	CU

France	Paris	IN2P3
Georgia	Tbilisi	GTU
		HEPI-TSU
		TSU
		UG
Germany	Dresden	TU Dresden
Japan	Fukuoka	Kyushu Univ.
	Osaka	Osaka Univ.
	Tsukuba	KEK
Kazakhstan	Almaty	INP
Russia	Moscow	ITEP
		NNRU "MEPhI"
	Novosibirsk	BINP SB RAS
		NSU
United Kingdom	London	Imperial College
	Didcot	RAL

02–1–1106–2011/2022	Priority: 1

Status: Extended

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, France, Germany, Poland, Romania, Russia.

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 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), 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** **O.V. Fateev**	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
France	Orsay	IPN Orsay
Germany	Darmstadt	GSI
		FAIR
		TU Darmstadt
	Dresden	HZDR
	Frankfurt/Main	Univ.
	Giessen	JLU
	Heidelberg	Univ.

	Munich	TUM
Poland	Krakow	SIP
Romania	Bucharest	IFIN-HH
Russia	Moscow	ITEP
		NNRU “MEPhI”
		SINP MSU
	Moscow, Troitsk	INR RAS

02–1–1096–2010/2022	Priority: 1

Status: Extended

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, Switzer-
land, 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'). (A') and other manifestation of Dark Sector. Tracking detectores based on the straw tube technology will be manifactured and supported. The software for data MC simulation and analysis will be prepared.

Expected results in the current year:

In frame of NA62:

1. NA62 and NA48/2 data analysis will be carried out.
2. 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.
3. Calibration and testing of the NA62 straw detectors will be carried out.

In frame of NA64:

1. NA64, analysis of the experimental data obtained during the 2017–2018 runs.
2. Development and put in operation of new track stations based on 6 mm straw tubes. Accompanying of detectors.
3. Equipment preparation for the 2021 run in the new experimental zone on the H4 SPS channel, CERN.

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 – 2022)

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, 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	V.E. Burtsev, T.L. Enik, A.A. Festchenko, A.V. Ivanov, 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	
DLNP	V.N. Frolov	

Collaboration

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

Mexico	San Luis Potosi	UASLP
Romania	Bucharest	IFIN-HH
Russia	Moscow	LPI RAS
	Moscow, Troitsk	INR RAS
		HPPI RAS
	Protvino	IHEP
	Tomsk	TPU
Slovakia	Bratislava	CU
Switzerland	Zurich	ETH
United Kingdom	Birmingham	Univ.
	Bristol	Univ.
	Glasgow	U of G
	Lancaster	LU
USA	Boston, MA	BU
	Fairfax, VA	GMU
	Menlo Park, CA	SLAC
	Merced, CA	UCMerced
	Upton, NY	BNL

02–0–1083–2009/2022	Priority: 1

Status: Extended

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 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 – 2023)
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, 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** **A.V. Zarubin**	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	
LIT	V.V. Palchik, N.N. Voytishin	
GA&C	B.S. Yuldashev	
4. **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, A.O. Golunov, N.V. Gorbunov, A.M. Kurenkov, V.A. Smirnov, E.V. Sukhov, T.V. Trofimov, V.V. Ustinov, N.I. Zamyatin, A.V. Zarubin	
5. **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	

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	GSU
Belgium	Brussels	ULB
		VUB
	Antwerp	UAntwerp
	Louvain-la-Neuve	UCL
	Mons	UMONS
Brazil	Rio de Janeiro, RJ	CBPF
		UERJ
		UFRJ
	Sao Paulo, SP	Unesp
Bulgaria	Sofia	INRNE BAS
		SU
CERN	Geneva	CERN
China	Beijing	IHEP CAS
		PKU
	Hefei	USTC
Croatia	Split	Univ.
Cyprus	Nicosia	UCY
Czech Republic	Prague	CU
Estonia	Tallinn	NICPB
Finland	Helsinki	HIP
		UH
	Jyväskylä	UJ
	Oulu	UO
	Tampere	TU
France	Annecy-le-Vieux	LAPP
	Lyon	IPNL
	Saclay	IRFU
	Strasbourg	IPHC
Georgia	Tbilisi	AIP TSU

		HEPI-TSU
Germany	Berlin	HU Berlin
	Aachen	RWTH
	Karlsruhe	KIT
Greece	Athens	INP NCSR "Demokritos"
		UoA
	Ioannina	UI
Hungary	Budapest	Wigner RCP
	Debrecen	Atomki
		UD
India	Bhubaneswar	IOP
	Chandigarh	PU
	Mumbai	BARC
		TIFR
Iran	Tehran	IPM
Italy	Rome	INFN
	Bari	INFN
	Bologna	INFN
	Catania	INFN LNS
	Florence	INFN
	Genova	INFN
	Padua	INFN
	Pavia	INFN
	Perugia	INFN
	Pisa	INFN
	Turin	INFN
Mexico	Mexico-City	Cinvestav
New Zealand	Auckland	Univ.
	Christchurch	UC
Pakistan	Islamabad	QAU
Poland	Warsaw	UW
	Otwock (Swierk)	NCBJ
Republic of Korea	Seoul	Konkuk Univ.
		KU
		SNUE
	Kwangju	CNU
	Naju	DU
	Namwon	SU
	Cheongju	CBNU
Russia	Moscow	ITEP
		LPI RAS
		NNRU "MEPhI"
		SINP MSU
	Moscow, Troitsk	INR RAS

	Dolgoprudny	MIPT
	Gatchina	NRC KI PNPI
	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
	Basel	Uni Basel
	Villigen	PSI
Taiwan	Taipei	NTU
	Taoyuan City	NCU
Turkey	Adana	CU
	Ankara	METU
Ukraine	Kharkov	NSC KIPT
		STC “IMK” NASU
		KhNU
United Kingdom	London	Imperial College
	Bristol	Univ.
	Didcot	RAL
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
	Evanston, IL	NU
	Gainesville, FL	UF
	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, AL	UA
Uzbekistan	Tashkent	INP AS RUz

02–0–1085–2009/2022	Priority: 1

Status: Extended

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 results in the current year:

- Measurement of π^0 production in the processes of exclusive deep inelastic scattering of muons on a hydrogen target.
- Measurements of Collins and Sivers asymmetry on hydrogen and deuterium targets.
- Measurement of semi-inclusive scattering on hydrogen and deuterium targets with 2 gadrons production.
- Measurement of transverse spin asymmetries in semi-exclusive scattering processes.
- 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**	**O.P. Gavrishchuk**	Maintenance
VBLHEP	V.A. Anosov, G.V. Meshcheryakov	
DLNP	A.S. Selyunin, A.V. Rybnikov	
2. **Electromagnetic calorimeter**	**A.P. Nagaytsev,** **N.V. Anfimov**	Maintenance
VBLHEP	V.A. Anosov, O.P. Gavrishchuk, G.V. Meshcheryakov, A.P. Nagaytsev	
DLNP	A.I. Antoshkin, V.M. Kudryavtsev, A.G. Olshevskiy, 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, O.M. Kuznetsov, G.V. Meshcheryakov, A.P. Nagaytsev, N.S. Rogacheva, D.V. Peshekhonov, I.A. Savin, E.A. Salmina	
DLNP	N.V. Anfimov, A.I. Antoshkin, A.F. Gridin, I.A. Denisenko, A.V. Maltsev, A.G. Olshevskiy, 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. Akhunzyanov, R. Guscherski, G.V Meshcheryakov, O.M. Kuznetsov, N.S. Rogacheva, V.D. Peshekhonov, E.A. Salmina, 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	A.V.Ivanov, Yu.I. Ivanshin, S.R.Gevorgyan, 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**
Belarus	Minsk	SPMRC NASB
CERN	Geneva	CERN
Czech Republic	Prague	CU
	Brno	BUT
	Liberec	TUL
France	Saclay	SPhN CEA DAPNIA
Germany	Bochum	RUB
	Bonn	UniBonn
	Freiberg	TUBAF
	Jülich	FZJ
	Munich	TUM
	Mainz	JGU
Israel	Tel Aviv	TAU
Italy	Trieste	INFN
	Turin	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: Being concluded

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" soft photons in proton and 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 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 prototype of electromagnetic calorimeter (from the BGO-crystal). Production of the necessary FE-electronics with low gamma-detection threshold ($\sim$ 5-8 MeV) for this calorimeter.
- Study and optimisation of scintillation light collection, computer simulation of electromagnetic shower profile in the detector cell on the base of W+Cu composite activated by cerium of gallium-gadolinium-garnet (GaGGiCe) for registration of soft photons.
- 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 nuclei (at the SVD-2 se-tup).

- R&D of silicon pixel detector for coordinate measurements.

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, 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, N. Barlykov, Yu.T. Borzunov, V.B. Dunin, V. Dudin, O.P. Gavrischuk, A.S. Gribovsky, V.I. Kireev, A.V. Konstantinov, D.A. Kirillov, V.A. Nikitin, V.A. Pavlyukevich, Yu.P. Petukhov, V.V. Popov, M.V. Tokarev, A.S. Savchenko, S.Yu. Sinelcshikova, R.A. Shindin, V.A. Zykunov	
BLTP	Yu.A. Bystritsky	

Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	BSUIR IAP NASB INP BSU IP NASB

		"Radatech"
	Gomel	GSTU
		GSU
Czech Republic	Prague	CTU
		CU
Japan	Osaka	RCNP
Russia	Moscow	"Azimuth-Photonics"
		NNRU "MEPhI"
		SINP MSU
		"FOMOS-MATERIALS"
	Protvino	IHEP
	St. Petersburg	SPbSPU
	Moscow, Zelenograd	RIMST
	Chernogolovka	ISSP RAS
	Syktyvkar	DM Komi SC UrB RAS
Slovakia	Banska Bistrica	UMB
Ukraine	Kiev	BITP NASU

02–0–1065–2007/2023	Priority: 1

Status: Extended

NICA Complex: Design and Construction of the Complex of Accelerators, Collider and Physics Experimental Facilities at Extracted and Colliding Ion Beams Aimed at Studying Dense Baryonic Matter and the Spin Structure of Nucleons and Light Ions, and at Carrying out Applied and Innovation Projects

Leaders: V.D. Kekelidze
A.S. Sorin

Deputies: A.D. Kovalenko
I.N. Meshkov
Yu.K. Potrebenikov

Participating countries and international organizations:

Armenia, Azerbaijan, Belarus, Bulgaria, CERN, Chile, China, Czech Republic, Egypt, France, Georgia, Germany, Italy, Israel, Kazakhstan, 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 proton and deuteron beams at the Nuclotron.

Expected results in the current year:

- Development and expansion of the physical programme of the project - "White Paper" of the NICA project. Obtaining new theoretical results for processes of strong interactions in the non-perturbative QCD region, development and tests of models for nuclear matter properties descriptions at extremely high temperatures and densities, investigation of possible nuclear matter states and nuclear 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: Construction on 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. UsingNuclotron beams for solving first-priority tasks on the accelerator development and of the NICA physics program implementation within in available running time. Designing the SC resonator prototype for the proton linear accelerator. Works on the designing proton and light ion linear accelerator LILAC.
- Commissioning of 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)
	Subproject 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)
4.	Conceptual and technical design of the SPD at the NICA collider	A.V. Guskov Deputy: V.P. Ladygin	1 (2020 – 2021)

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 transporting to the Nuclotron)**	**A.V. Butenko** **A.I. Govorov** **V.V. Kobets** **A.D. Kovalenko** **V.A. Monchinsky**	Realization

1.1.a.	**Commissioning of 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 construction 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, 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**	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 transport 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.I. 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, 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**	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, A.D. Kovalenko, 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**	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.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, 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, construction 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, 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 project**	**V.M. Golovatyuk** **V.D. Kekelidze**	Realization
	VBLHEP	H.U. Abraamyan, G.S. Averichev, A.V. Averiyanov, G.N. Agakishiev, T.V. Andreeva, A.B. Anisimov, V.A. Babkin, M.Yu. Barabanov, 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.N.Meshkov, 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**	Realization
	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**	Realization
	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**	Realization
	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. Blaschke** **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	Yu.I.Bulaev, V.F. Dydyshko, O.S. Fedoseev, D.G. Mel'nikov, Yu.I.Minaev, D.V. Peshekhonov, I.P. Slepov, B.G. Schinov, I.V. Slepnev, S.N. Shkarovsky, V.L. Svalov, A.V.Turmanov	

	LIT	D.V. Kekelidze, V.V. Koren'kov, M.S. Plyashkevich, T.A. Strizh	
6.	**SPD project: conceptual and technical design of the Spin Physics Detector (SPD) at the NICA collider**	**A.D. Kovalenko** **V.P. Ladygin**	Project preparation
	VBLHEP	R.R. Akhunzyanov, V.A. Anosov, N.I. Azorsky, A.A. Baldin, E.G.Baldina, M.Yu. Barabanov, A.N. Beloborodov, A.V.Belyaev, V.V.Bleko, D.N.Bogoslovsky, I.V. Boguslavsky, V.B. Dunin, Yu.N. Filatov, T.L. Enik, O.P. Gavrischuk, A.S. Galoyan, L.Glonti, N.O.Grafov, A.S. Gribovsky, V.A.Gromov, Yu.V. Gurchin, Yu.V. Gusakov, A.V. Ivanov, Yu.A.Ivanova, A.Yu. Isupov, G.D. Kekelidze, M.A. Kozhin, E.S. Kokoulina, E.V. Kostyukhov, Yu.A. Kopylov, D.S. Korovkin, V.A. Kramarenko, V.N. Kruglov, S.V. Khabarov, P.R. Kharyuzov, A.N. Khrenov, V.P. Ladygin, V.M. Lysan, R. Lednický, A.M. Makan'kin, G.V. Mescheryakov, I.V. Moshkovsky, S.N.Nagorny, V.A. Nikitin, V.V. Pavlov, S.S. Parzhitsky, E.E. Perepelkin, D.V. Peshekhonov, V.V.Popov, S.G. Reznikov, O.V. Rogachevsky, A.B.Safonov, I.A. Savin, A.A. Savenkov, S.Yu. Starikova, Ya.T. Skhomenko, E.A. Streletskaya, O.G. Tarasov, O.V. Teryaev, A.V. Tishevsky, N.D. Topilin, B.L. Topko, Yu.A.Troyan, E.A. Usenko, A.I. Sheremetieva, S.S. Shimansky, E.V. Vasilieva, P.V. Volkov, I.P. Yudin, N.I. Zamyatin, I.A. Zhukov, 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. Guskov, M. Finger, M. Finger(Jr.), V.N. Frolov, V.I.Komarov, A.V. Kulikov, V.S.Kurbatov, 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, A.N.Skachkova, M. Slunečka, V. Slunečkova, V.V.Tereschenko, A.V. Tkatchenko, V.V. Tokmenin, D.A.Tsirkov, Yu.N. Uzikov, L.S. Vertogradov, Yu.L.Vertogradova, 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, 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	Foundation ANSL
		YSU
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	BSUIR
		INP BSU
		IP NASB
		JIPNR-Sosny NASB
		SPMRC NASB
		PTI NASB
	Gomel	GSU
Bulgaria	Sofia	INRNE BAS

		ISSP BAS
		LTD BAS
		TU-Sofia
		SU
	Blagoevgrad	SWU
	Plovdiv	PU
CERN	Geneva	CERN
China	Beijing	"Tsinghua"
		UCAS
	Shanghai	SINAP CAS
	Hefei	IPP CAS
		USTC
	Huzhou	HU
	Lanzhou	IMP CAS
	Wuhan	CCNU
	Yichang	CTGU
Chile	Valparaiso	UTFSM
Czech Republic	Prague	CU
		CTU
	Liberec	TUL
	Olomouc	UP
	Prague	CU
		CTU
	Řež	NPI CAS
	Vitkovice	VHM
France	Nantes	SUBATECH
	Saclay	CEA
Egypt	Cairo	ECTP
Germany	Darmstadt	GSI
		TU Darmstadt
	Dresden	ILK
	Erlangen	FAU
	Frankfurt/Main	FIAS
		Univ.
	Giessen	JLU
	Jülich	FZJ
	Mainz	JGU
	Tübingen	Univ.
	Regensburg	UR
Japan	Nagoya	Nagoya Univ.
Georgia	Tbilisi	AIP TSU
		GTU
Italy	Brescia	Forgiatura Morandini
	Genova	ASG

	Turin	INFN
Israel	Tel Aviv	TAU
	Jerusalem	HUJI
Kazakhstan	Almaty	PhysTI
Mexico	Mexico-City	UNAM
	Puebla	BUAP
Moldova	Chişinău	MSU
		IAP
Mongolia	Ulaanbaatar	IPT MAS
Poland	Warsaw	WUT
	Chorzow	Frako-Term
	Lublin	UMCS
	Otwock (Swierk)	NCBJ
	Wroclaw	ILT&SR PAS
		UW
Romania	Bucharest	IFIN-HH
		INCDIE ICPE-CA
	Magurele	INOE2000
Russia	Moscow	Cryogenmash
		Geliymash
		IBMP RAS
		ITEP
		LPI RAS
		MSU
		NNRU “MEPhI”
		NRC KI
		SINP MSU
		”SINTEZ-PROJECT”
		VEI
	Moscow, Troitsk	INR RAS
	Belgorod	BelSU
	Gatchina	NRC KI PNPI
	Dolgoprudny	MIPT
	Dubna	PELCOM
		Progresstech
	Kazan	Compressormash
		Spetshmash
	Novosibirsk	BINP SB RAS
		STL “Zaryad”
	Protvino	IHEP
	Samara	SU
	St. Petersburg	Neva-Magnet
		KRI
		SPbSU

		SPbSPU
	Syktyvkar	DM Komi SC UrB RAS
	Tomsk	NPI TPU
		TPU
		TSU
	Fryazino	ISTOK
	Vladikavkaz	NOSU
	Chernogolovka	LITP RAS
Slovakia	Bratislava	IMS SAS
	Košice	UPJS
	Žilina	UŽ
South Africa	Cape Town	UCT
	Johannesburg	UJ
		WITS
Sweden	Stockholm	SU
Ukraine	Kiev	BITP NASU
	Kharkov	KhNU
		LTU
		NSC KIPT
USA	Batavia, IL	Fermilab
	Cambridge, MA	MIT
	Stony Brook, NY	SUNY
	Upton, NY	BNL

02–0–1127–2016/2023	Priority: 1

Status: In-progress

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:

Creating a network of six Precision Laser Inclinometers (PLI); creating a prototype of an amplitude interferometric length meter for a length of 16 m; creating a prototype of a laser reference line for a length of 128 m; creating a prototype of a seismic-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 results in the current year:

- Fabrication of the nanostructured carbon photocathodes and investigation of their electrophysical properties (λ = 213 / 266 nm). Assembling of the pepper-pot emittance measurement system main components for the Photoinjector bench. Vacuum system assembling and pumping. Design, fabrication and assembling of the cryopump for the bench vacuum system. Assembling, tuning and calibration of the nanosecond range high-sensitivity electron bunch charge sensor prototype. Bench startup with 120 keV energy.

- Optimization of the Linac-200 beam parameters at 200 MeV energy. Extraction of the beam with wide range parameters from single electrons to 30 mA with repetition 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. Modernization of the cooling, control and interlock systems

- Development and creation of an absolute length meter with micron resolution for lengths of 1-10 m. Determining the sensitivity of the meter on a length of 0.42 m. R&D on the creation of a 128-meter laser reference line with the ability to measure the spatial position of the Measured Point on a controlled object (non-destructive testing).

  Measurement of microseismic activity at CERN and assessment of the effect of microseisms on the luminosity of the LHC collider, development of technical specifications for the design and software of small-sized PLI.

- 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 of the JINR participation in international collaborations for future high-energy colliders. Analysis of 6 T high efficient dipole magnets aimed at the FCC "low energy" pp-collider option at CERN.

List of projects:

	Project	Leader	Priority (period of realization)
1.	Precision laser metrology for accelerators and detector complexes	Yu.A. Budagov M.V. Lyablin	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, 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	
	BLTP	A.N. Baushev	
	GA&C	G.V. Trubnikov	
4.	**Free electron lasers R&D**	**E.M. Syresin** **O.I. Brovko** **M.V. Yurkov**	Technical proposal
	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	Yerevan	Shirak Technologies
	Garni	GGO
	Gyumri	IGES NAS RA
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: In-progress

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 results in the current year:

- Works:
  a) complation of preparation of the project of low energy proton and deuteron polarimeter at the Nuclotron injection channel;
  b) work on the 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. Development and manufacture of the proton polarimeter at the Nuclotron internal target. Analysis of the data on the analyzing powers A_y, A_{yy} and A_{xx} in deuteron–proton elastic scattering at the energies 400–1300 MeV. Publication and reports of the results.
- 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).
- 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, A.A. Kolomiets, M.Yu. Korobitsyna, 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. Livanov, 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	

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	CTU
		CU
	Brno	ISI CAS
	Liberec	TUL
	Řež	UJV
France	Orsay	IPN Orsay
	Saclay	IRFU
Germany	Bochum	RUB
	Dresden	TU Dresden
	Freiburg	FMF
	Jülich	FZJ
	Tübingen	Univ.
Japan	Tokyo	UT
	Hiroshima	Hiroshima Univ.
	Osaka	RCNP
Poland	Otwock (Swierk)	NCBJ
Romania	Bucharest	INCDIE ICPE-CA
Russia	Moscow	LPI RAS
		NRC KI
	Moscow, Troitsk	INR RAS
		LPP LPI RAS
	Gatchina	NRC KI PNPI

Slovakia	Bratislava	IP SAS
	Košice	IEP SAS
		UPJS
	Žilina	UŽ
Sweden	Uppsala	TSL
Switzerland	Villigen	PSI
Ukraine	Kharkov	NSC KIPT
United Kingdom	Glasgow	U of G
USA	Newport News, VA	JLab
	Norfolk, VA	NSU
	Upton, NY	BNL
	Williamsburg, VA	W&M
Uzbekistan	Tashkent	Assoc."P.-S." PTI
		INP AS RUz

02–1–1087–2009/2020	Priority: 1

Status: Being concluded

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) and PHENIX(BNL). 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 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. Upgrading of TOF system.
- 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.
- 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.
- Processing of experimental data from RUN 5-9 of the PHENIX installation. Participation in the development of the program on e-RHIC.

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 – 2022)

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, A.V.Dmitriev, V.M.Golovatyuk, 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	H.U.Abraamyan, V.Karcz, L.V.Karnyushina, A.G.Litvinenko, Z.A.Igamkulov, V.F.Peresedov, P.A.Rukoyatkin, Z.Ya.Sadygov	
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, 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	R.A.Akbarov, H.U.Abraamyan, T.Yu.Bokova, Z.A.Igamkulov, L.V.Karnyushina, I.I. Migulina, V.F. Peresedov, A.Z.Sadygov, Z.Ya.Sadygov	
	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

11. **Processing data from previous PHENIX RUNs. Preparation of the measurement program at eRHIC.** — **A.G. Litvinenko** — Upgrade, Data analysis

VBLHEP — S.V.Afanasiev, A.Yu.Isupov, A.I.Malakhov, P.A.Rukoyatkin, V.F.Peresedov, S.P.Avdeev, Y.U.Abraamyan

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL
		YSU
Bulgaria	Sofia	INRNE BAS
		Inst. Microbiology BAS
		SU
	Blagoevgrad	AUBG
CERN	Geneva	CERN
China	Beijing	CIAE
		IHEP CAS
	Wuhan	CCNU
Czech Republic	Prague	IMC CAS
	Řež	NPI CAS
Germany	Darmstadt	TU Darmstadt
	Frankfurt/Main	FIAS
		Univ.
	Heidelberg	MPIK
Japan	Tsukuba	Univ.
India	Jaipur	Univ.
	Mumbai	BARC
Kazakhstan	Almaty	PhysTI
Mongolia	Ulaanbaatar	IPT MAS
Poland	Warsaw	WUT
		UW
	Krakow	NINP PAS
	Lodz	UL
	Otwock (Swierk)	NCBJ
Romania	Bucharest	IFIN-HH
		INCDIE ICPE-CA

		UB
	Constanţa	UOC
	Magurele	ISS
Russia	Moscow	ITEP
		LPI RAS
		SINP MSU
	Moscow, Troitsk	INR RAS
	Chernogolovka	ISMAN RAS
	Protvino	IHEP
	Smolensk	SSU
	St. Petersburg	FIP
	Sarov	VNIIEF
	Tomsk	TPU
	Vladikavkaz	VTC “Baspik”
Slovakia	Bratislava	IP SAS
	Košice	UPJS
Switzerland	Geneva	UniGe
USA	Berkeley, CA	Berkeley Lab
	Iowa City, IA	UIowa
	Upton, NY	BNL
Uzbekistan	Tashkent	Assoc.“P.-S.” PTI
	Jizzakh	JSPI
	Samarkand	SSU

02–0–1066–2007/2020	Priority: 1

Status: Being concluded

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:

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 results in the current year:

- The data on beam energy scan at 19.6 GeV and 14.6 GeV.
- The data of global polarization in gold-gold collisions.
- 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	
7.	**Elaboration of proposals for the development of detectors for the study of polarization phenomena at colliders**	**V.B. Dunin**	Realization
	VBLHEP	V.B. Dunin + 2 pers., A.D. Kovalenko, V.V. Fimushkin	

Collaboration

Country or International Organization	City	Institute or Laboratory
Azerbaijan	Baku	IRP ANAS
Bulgaria	Sofia	INRNE BAS
		SU
Czech Republic	Prague	CU
	Řež	NPI CAS
		UJV
France	Nantes	SUBATECH
Germany	Heidelberg	Univ.
Poland	Warsaw	WUT
Russia	Moscow	ITEP
		NNRU "MEPhI"
	Protvino	IHEP
	St. Petersburg	SPbSU
Slovakia	Bratislava	IP SAS
	Košice	UPJS
USA	Berkeley, CA	Berkeley Lab
	Bloomington, IN	IU
	Lemont, IL	ANL
	New Haven, CT	Yale Univ.
	University Park, PA	Penn State
	Upton, NY	BNL

02–1–1088–2009/2022	Priority: 1

Status: Extended

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 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 – 2023)
2.	R&D for the ALICE photon spectrometer	A.S. Vodopyanov	1 (2010 – 2020)

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, S.C.Ceballos	

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, G.E. Romanenko, K. Roslon, V.D. Rumyantsev, Yu.L. Vertogradova	
	DLNP	G.I. Lykasov	
	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	SINP
		VECC
	Chandigarh	PU
	Jammu	Univ.
Italy	Bari	INFN
	Bologna	INFN
	Cagliari	INFN
	Catania	INFN LNS
	Legnaro	INFN LNL
	Padua	INFN
	Rome	INFN
	Salerno	INFN
	Turin	INFN
	Vercelli	UPO
Netherlands	Amsterdam	NIKHEF
	Utrecht	UU
Norway	Bergen	UiB
	Oslo	UiO
Poland	Warsaw	IEL
		WUT
	Krakow	NINP PAS
	Otwock (Swierk)	NCBJ
Republic of Korea	Gangneung	GWNU
Romania	Magurele	ISS
Russia	Moscow	ITEP
		NNRU "MEPhI"
		NRC KI
		SINP MSU
	Moscow, Troitsk	INR RAS
	Gatchina	NRC KI PNPI
	Novosibirsk	BINP SB RAS
	Protvino	IHEP
	Sarov	VNIIEF
	St. Petersburg	FIP
Slovakia	Bratislava	STU
	Košice	UPJS
South Africa	Cape Town	UCT
Sweden	Lund	LU
Switzerland	Lausanne	EPFL
Ukraine	Kiev	BITP NASU

	Kharkov	NSC KIPT
United Kingdom	Birmingham	Univ.
USA	Columbus, OH	OSU
	Oak Ridge, TN	ORNL

02–1–1107–2011/2021	Priority: 1

Status: Extended

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 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 (Energy & Transmutation, radiation materials science)	S.I. Tyutyunnikov	1 (2018 – 2020)

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
		ISEI BSU
		RI PCP BSU
Bulgaria	Sofia	INRNE BAS
Czech Republic	Prague	CTU
	Brno	BUT
	Řež	UJV
Moldova	Chişinău	IAP
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	IFIN-HH
		UMF
	Magurele	ISS
	Magurele	ISS
	Baia Mare	TUCN-NUCBM
	Timişoara	UVT
	Iaşi	UAIC
Slovakia	Bratislava	CU
		IP SAS
		SOSMT
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:

Belarus, Belgium, Bulgaria, CERN, China, Canada, 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 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 with design parameters at the SHE Factory. Preparation for experiments on the synthesis of a new element 120.
- Construction of a pre-separator for the 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. Expansion of the infrastructure of the ACCULINNA-2 fragment separator (RF-kicker).
- Commencement of work on the upgrade of the U-400M cyclotron.
- Development of the project on the U-400 (U-400R) experimental hall construction.
- Implementation of the experimental programme on the synthesis and study of superheavy nuclei and on the spectroscopy of heavy nuclei employing 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 (installation of detecting devices) and first experiments with heavy-ion beams.
- Preparation of technical assignments for the manufacture of separate nodes of the gas ion catcher and the placement of manufacture orders.
- Preparation of technical assignments for development of the project of a demonstrator consisting of an ECR 14-GHz ion source and cw-RFQ sections.

List of projects:

	Project	Leader	Priority (period of realization)
1.	Construction of a prototype of the initial section of a high-current heavy-ion linear accelerator aimed at producing intense radioactive ion beams for basic research	L.V. Grigorenko T.V. Kulevoy	1 (2020 – 2021)

List of activities:

	Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers	Status
1.	**Development of the Superheavy 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.D. Shubin, V.G. Subbotin, I.V. Shirokovsky, M.V. Shumeiko, 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	
10.	**Design and manufacturing of the linac front-end demonstrator**	**L.V. Grigorenko**	Preparation
	FLNR	S.L. Bogomolov, A.A. Efremov, A.A. Bezbakh, A.V. Gorshkov, S.A. Krupko, G.M. Ter-Akopian, A.S. Fomichev, P.G. Sharov	
	VBLHEP	A.V. Butenko, E.M. Syresin	

Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	SPMRC NASB
Belgium	Leuven	KU Leuven
	Louvain-la-Neuve	IBA
Bulgaria	Sofia	INRNE BAS
Canada	Vancouver	TRIUMF
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
	Padua	INFN
Kazakhstan	Nur-Sultan	BA INP
Mongolia	Ulaanbaatar	NRC NUM
Poland	Warsaw	HIL WU
		IEP WU
	Krakow	NINP PAS
Romania	Bucharest	IFIN-HH
	Magurele	N&V
Russia	Moscow	HTDC
		ITT-Group
		MSU
		NNRU "MEPhI"
		ITEP
	Moscow, Troitsk	INR RAS
	Gatchina	NRC KI PNPI
	Nizhny Novgorod	IAP RAS
	Sarov	VNIIEF
	St. Petersburg	NIIEFA
		IAI RAS
	Snezhinsk	VNIITF
Serbia	Belgrade	INS "VINČA"
Slovakia	Bratislava	IMS SAS
		IP SAS
	Nova Dubnica	EVPU
South Africa	Faure	iThemba LABS
Ukraine	Kiev	KINR NASU
Uzbekistan	Samarkand	SSU
USA	College Station, TX	Texas A&M
	East Lansing, MI	MSU
	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 results in the current year:

- Experiments on the synthesis of Mc isotopes in the ^{48}Ca + ^{243}Am reaction at the SHE Factory.
- Experiments on the synthesis of Fl isotopes in the ^{48}Ca + ^{242}Pu reaction aimed at studying the chemical properties of Fl using the DGFRS-2 separator.
- Preparation for and the launch of experiments on the synthesis of elements 119 and 120 in the complete fusion reactions with ^{50}Ti projectiles.
- Experiments on the study of the decay properties (α-, β-, γ-spectroscopy) of Sg isotopes and heavy isotopes of Rf formed in the reactions with ^{54}Cr and ^{22}Ne using the SHELS + GABRIELA separator. Experiments on measuring the multiplicity of prompt neutrons from the spontaneous fission of heavy Rf isotopes in the reactions with ^{22}Ne. Test experiment on the spectroscopy of the decay properties of the ^{288}Mc isotopes and its daughter products in the ^{48}Ca + ^{243}Am reaction.
- Experiments on the study of the chemical properties of Db and Nh in the ^{48}Ca + ^{243}Am reaction. Preparation for chemistry experiments at the SHE Factory.
- Analysis of experiments conducted with the MASHA set-up aimed at studying the operational stability of a new design of the hot catcher for the separation of short-lived mercury and radon isotopes synthesized in complete fusion reactions.
- Investigation of the mass-energy and angular distributions of fragments produced in the ^{44}Ca + ^{206}Pb reaction. Study of the mechanism of multinucleon transfer in the ^{136}Xe + ^{194}Pt reaction. Study of multi-body decays of low-excited heavy nuclei. Study of the multicluster decay of heavy and superheavy nuclei. Development of physics set-ups.
- Study of nuclei with $Z < 20$ near the boders of nucleon stability. Investigation of the structure of the exotic nuclei ^{7}He, ^{10}Li, ^{26}Si, and ^{25}P using radioactive ion beams at the ACCULINNA-1 and ACCULINNA-2 set-ups.
- Experiments conducted at the MAVR set-up for the study of fast charged particles in coincidence with recoil nuclei aimed at determining the reaction mechanism for experiments on the synthesis of new elements. Study of the yields of products in multinucleon transfer reactions. Measurement of total reaction cross sections using low-intensity beams of exotic nuclei.
- Theoretical studies of the mechanisms of heavy-ion-induced reactions.
- Maintenance and update of the web 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.D. Shubin, V.G. Subbotin, I.V. Shirokovsky, M.V. Shumeiko, 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.A. Astakhov, A.Yu. Bodrov, G.A. Bozhikov, I. Chuprakov, N.S. Gustova, K.V. Lebedev, A.Sh. Madumarov, E.V. Melnik, A.V. Sabelnikov, G.Ya. Starodub, G.K. Vostokin, M.G. Voronyuk	
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, T. Banerjee, 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, D. Kumar, C.H. Meghashree, 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, V. Chudoba, M.S. Golovkov, L.V. Grigorenko, A.V. Gorshkov, E.M. Gazeeva, V.A. Gorshkov, A. Ismailova, G. Kaminski, S.A. Krupko, S.A. Klygin, G.A. Kononenko, K.A. May, B. Mauyey, I.A. Muzalevskiy, E.Yu. Nikolskii, Yu.L. Parfenova, W. Piatek,, S.A. Rimzhanova, Yu.M. Sereda, S.I. Sidorchuk, R.S. Slepnev, P.G. Sharov, S.V. Stepantsov, A. Swiercz, P. Szymkiewicz, 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, T. Isataev, S.M. Lukyanov, V.A. Maslov, K.O. Mendibaev, R.V. Revenko, I. Sivacek, N.K. Skobelev, Yu.G. Sobolev, V.I. Smirnov, S.S. Stukalov, D.A. Testov, V.A. Zernyshkin

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	Beijing	PKU

	Lanzhou	IMP CAS
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
	Rupnagar	IIT Ropar
	Roorkee	IIT Roorkee
Italy	Catania	INFN LNS
	Legnaro	INFN LNL
	Messina	UniMe
	Naples	Unina
Japan	Wako	RIKEN
	Tokai	JAEA
Kazakhstan	Nur-Sultan	ENU
	Almaty	INP
		IETP KazNU
Mongolia	Ulaanbaatar	NRC NUM
Poland	Warsaw	UW
	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
		SPbSU
	Voronezh	VSU
Slovakia	Bratislava	CU
		IP SAS
South Africa	Pretoria	UNISA
	Faure	iThemba LABS
	Stellenbosch	SU
Spain	Huelva	UHU
Switzerland	Villigen	PSI
Sweden	Göteborg	Chalmers
	Lund	LU
Ukraine	Kiev	KINR NASU
United Kingdom	Manchester	UoM
USA	Lemont, 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: In-progress

Non-Accelerator Neutrino Physics and Astrophysics

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

Participating countries and international organizations:

Azerbaijan, Bulgaria, Czech Republic, Finland, France, Germany, Kazakhstan, Poland, Russia, Slovakia, 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, and 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, and search for exotic particles (monopoles). Use of the neutrino detector for a distant investigation of processes inside of the reactor core of the 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 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 the 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 the neutrino magnetic moment at the sensitivity level 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, determination of parameters for light dark matter for the mass region below 1 GeV/c^2.
- 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 6th and 7th 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 for 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	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.B. Brudanin, D.V. Filosofov, I.I. Kamnev, D.V. Karaivanov, F.F. Klimenko, M.A. Mirzaev, I.B. Nemchenok, A.V. Rahimov, A.V. Salamatin, A.A. Smolnikov, Yu.A. Shitov V.V. Timkin, V.I. Tretyak, O.V. Vagina	
	BLTP	F. Simkovic	
2.	**Investigation of $2K2\nu$ and $2K0\nu$ decays of ^{106}Cd with the TGV spectrometer**	**N.I. Rukhadze** **I. Shtekl**	Data taking
	DLNP	S.L. Katulina, A.V. Salamatin, V.G. Sandukovskiy, V.V. Timkin	
	BLTP	F. Simkovic	
3.	**G&M (GERDA–MAJORANA Project)**	**K.N. Gusev**	Preparation Data taking
	DLNP	V.B. Brudanin, D. Borowicz, M.V. Fomina, A.A. Klimenko, O.I. Kochetov, A.V. Lubashevsky, I.B. Nemchenok, S.M. Nepochatich, N.S. Rumyantseva, V.G. Sandukovsky, E.A. Shevchik, M.V. Shirchenko, A.A. Smolnikov, 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.B. Brudanin, M.V. Fomina, Z. Kalaninova, A.V. Lubashevsky, D.V. Medvedev, D.V. Ponomarev, V.G. Sandukovsky, M.V. Shirchenko, S.V. Rozov, I.E. Rozova, I.V. Zhitnikov, D.R. Zinatulina, E.A. Yakushev	
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, S.V. Rozov, I.E. Rozova, K.V. Shakhov, E.A. Yakushev	
6.	**BAIKAL Project**	**I.A. Belolaptikov** **V.B. Brudanin**	Preparation Data taking
	DLNP	P.I. Antonov, R. Dvornicky, A.A. Doroshenko, K.V. Golubkov, N.A. Gorshkov, M.S. Katyulin, A.A. Klimenko, M.M. Kolbin, K.V. Konishev, A.V. Korobchenko, M.V. Kruglov, M.B. Milenin, V. Nazari, T. Orazgali, D.A. Orlov, D.P. Petukhov, E.N. Pliskovski, I.E. Rozova, V.D. Rushay, A.V. Salamatin, G.B. Safronov, S.I. Sinegovsky, A.A. Smolnikov, M.N. Sorokovnikov, N.I. Sosunov, I.A. Stepkin, E.V. Khramov, B.A. Shaybonov, M.V. Shirchenko	
7.	**Investigation of spectra of low-energy electrons after radioactive decays to obtain data for atomic and nuclear physics and for nuclear medicine. Development of ultrastable energy calibration for the KATRIN neutrino project. Investigation of decays of rear-earth radionuclides and structure of their excited states**	**A.Kh. Inoyatov,** **A. Kovalik**	Data taking
	DLNP	N.V. Morozova,V.A. Morozov, L.L. Perevoshikov, V.I. Stegailov, A.A. Solnyshkin, D.V. Filosofov	
	FLNR	I.N. Izosimov	
8.	**Radiochemical support of irradiation of targets, separation of radionuclides from them by radiochemistry and mass separation methods, preparation of ionizing radiation sources for physical research at DLNP; chemical, radiochemical and mass separator support of low-background measurements for neutrino physics**	**D.V. Filosofov**	Preparation
	DLNP	Yu.A. Vaganov, A.I. Velichkov, D.V. Karaivanov, A.A. Solnyshkin, J.A. Dadakhanov, E.S. Kurakina, A.E. Baimukhanova, A.V. Rakhimov, N.A. Mirzayev	

9. **Development of methods for the separation of elements (radiochemistry and mass separation); development of methods for obtaining radioisotopes for nuclear medicine and the synthesis of radiopharmaceuticals based on them; development and manufacture of micro sources for cancer brachytherapy; study of the physicochemical properties of condensed matter using the method of perturbed angular correlations of nuclear radiation** — **D.V. Filosofov** — Preparation

   DLNP: Yu.A. Vaganov, A.I. Velichkov, D.V. Karaivanov, A.A. Solnyshkin, A.V. Salamatin, D.A. Salamatin, N.T. Temerbulatova, E.S. Kurakina, J.K. Samatov

   FLNR: G.A. Bozhikov

10. **Development and production of low-energy-threshold HPGe detectors. Development and production of special types of Si and Ge detectors for low background measurements. Development and production of plastic scintillators for low-background spectrometers, neutron detectors, and cosmic muon detection. Development and production of a muon detection network for continuous atmosphere control in the Moscow region** — **V.B. Brudanin**, **E.A. Yakushev** — Preparation

    DLNP: D. Borowicz, Yu.B. Gurov, L. Grubchin, K.N. Gusev, S.L. Katulina, I.B. Nemchenok, D.V. Ponomarev, S.V. Rozov, V.G. Sandukovskiy

    FLNR: A.M. Rodin

    VBLHEP: N.I. Zamyatin

11. **DANSS Project** — **V.B. Brudanin** — Preparation

    DLNP: V.V. Belov, V.B. Brudanin, M.V. Fomina, S.V.Kazartsev, A.S. Kuznetsov, D.V. Medvedev, A.G. Olshevsky, I.E. Rozova, N.S. Rumyantseva, M.V. Shirchenko, E.A. Shevchik, Yu.A. Shitov, D.R. Zinatulina, I.V. Zhitnikov

Collaboration

Country or International Organization	City	Institute or Laboratory
Azerbaijan	Baku	IRP ANAS
Bulgaria	Sofia	INRNE BAS

	Plovdiv	PU
Czech Republic	Prague	CTU
	Řež	NPI CAS
Finland	Jyväskylä	UJ
France	Orsay	CSNSM
	Grenoble	UGA
	Lyon	IPNL
	Modan	LSM
	Saclay	CEA
Germany	Mainz	JGU
	Munich	TUM
	Karlsruhe	KIT
Kazakhstan	Almaty	INP
Mongolia	Ulaanbaatar	IPT MAS
Poland	Lublin	UMCS
Russia	Moscow, Troitsk	INR RAS
		HPPI RAS
	Moscow	ITEP
		NNRU "MEPhI"
		SC "VNIINM"
		SINP MSU
	Dubna	Dubna State Univ.
	Gatchina	NRC KI PNPI
	Neutrino	BNO INR RAS
	St. Petersburg	FIP
	Tomsk	NPI TPU
		IHCE SB RAS
	Voronezh	VSU
Slovakia	Bratislava	CU
		IEE SAS
United Kingdom	London	UCL
	Manchester	UoM
Uzbekistan	Tashkent	INP AS RUz

03–2–1102–2010/2020	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 results in the current year:

- Modernization of the power control systems for the high-frequency modulator and generator of the Phasotron.
- Development of physical and technical methods and codes for design of new cyclotron-type accelerators.
- Measurements of the magnetic field in the manufactured magnet of the SC202 cyclotron and analysis of the results. Formation of the magnetic field.
- Participation in the commissioning of the SC202 cyclotron in IPP (Hefei, China).
- Participation in production of a bending 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, S.B. Vorozhtsov, V.A. Utkin	
2. **Design of the cyclotrons for medical purpose**	**G.A. Karamysheva**	Technical proposal
DLNP	S.B. Fedorenko, 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, I.M. Sedyh, S.G. Shirkov, S.B. Vorozhtsov, V.L. Smirnov	
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, S.B. Fwdorenko, 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 physical and technical methods and codes for design of new cyclotron-type accelerators**	**S.B. Vorozhtsov**	Realization
	DLNP	V.L. Smirnov, V.M. Romanov	

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	QST-NIRS
Poland	Krakow	NINP PAS
USA	Lansing, MI	IONETIX
Uzbekistan	Tashkent	INP AS RUz

03-4-1128-2017/2022	Priority: 1

Status: Extended

Investigations of Neutron Nuclear Interactions and Properties of the Neutron

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

Participating countries and international organizations:

Albania, Australia, Austria, Azerbaijan, Belarus, Belgium, Bulgaria, CERN, China, Croatia, Czech Republic, Egypt, Finland, France, Germany, 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 results in the current year:

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

- Development and testing of a new experimental method for measuring the ROT effect in fission on polarized neutron beams.
- Measurement of rare fission modes with Timepix detectors.
- Precision measurement of yields and angular correlations of γ-rays and neutrons in the interaction of 14 MeV neutrons with nuclei.
- Investigation of the variations of multiplicities of fission neutrons and TKE in the reaction $^{235}U(n_{res}, f)$ at the IREN facility. Investigation of the $(n, \gamma f)$ process in the reaction $^{239}Pu(n_{res}, f)$.
- Investigation of fast neutron induced reactions (n, p), (n, α) for light nuclei (Cl, N) using an ionization chamber and position-sensitive detectors Timepix3.

Investigation of fundamental properties of the neutron, UCN physics:

- Creating samples of nanodiamond powders with reduced content of metallic impurities and reduced content of elements with large neutron capture cross section to create low-energy nanoparticle reflectors.
- Measurements of small-angle neutron scattering with the obtained samples to determine their characteristics (size of crystals, agglomerates, etc.).
- Measurements of the quasi-mirror reflection of VCN from a sample with crystallites of $\sim$20 nm in size.
- Conducting detailed quantum calculations and preparing a draft experimental setup for a non-stationary quantum experiment on the interaction of neutrons with a neutron interference filter oscillating in space.

- Conducting an experiment on the inelastic heating of UCNs on surface acoustic waves and checking the validity of the model of the effective potential in the case of a substance moving with extreme acceleration of the order of $10^7 g$.

Applied and methodological research:

- Development of the data acquisition system for measurements of the time-of-flight spectra by the current method.
- Modernization of the neutron guide of the 1st channel of the IBR-2 reactor.
- Investigation of the depth profiles of all elements contained in the surface layers of solid-state samples.
- Elemental and isotopic analysis of archaeological samples at the IREN facility using the method of neutron resonance spectrometry and the method of neutron activation analysis.
- Modernization of the REGATA facility at the IBR-2 reactor.
- Elemental analysis of plant, biological, geological samples, as well as new materials, including nanomaterials, by means of the neutron activation analysis method at the IBR-2 reactor using the REGATA facility.
- The use of low-background gamma spectrometry to analyze the content of radionuclides in environmental objects.
- Development of an automated post for carrying out neutron activation analysis at the Institute of Nuclear Physics (Alma-Ata, Kazakhstan).
- Development of a prototype facility for elemental analysis using TNM and high-resolution gamma-ray detectors.

Development of the IREN facility

- Providing the neutron beam time from IREN for physical experiments.

List of projects:

	Project	Leader	Priority (period of realization)
1.	TANGRA	Yu.N. Kopatch	1 (2014 – 2022)

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, D. Berikov, S.B. Borzakov, B. Buadze, I.I. Chuprakov, G.V. Daniljan, 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, S.V. Mironov, V.V. Novitsky, I.A. Oprea, K.D. Oprea, Yu.N. Pokotilovskij, A.B. Popov, P.V. Sedyshev, M.V. Sedysheva, O.V. Sidorova, N.V. Simbirtseva, V.R. Skoj, A.M. Suhovoj, S.A. Telezhnikov, T.Yu. Tretyakova, M. Tsulaja, Vu Dyk Kong, Sh.S. Zeynalov, 24 engineers, 4 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, A.Yu. Nezvanov, Yu.N. Pokotilovskij, N.Yu. Rebrova, A.V. Strelkov, E.I. Sharapov, M.A. Zakharov, K.N. Zhernenkov, 2 engineers, 1 worker	
3.	**Applied research**	**P.V. Sedyshev**	Upgrade Data taking Data analysis
	FLNP	M.V. Frontasyeva, A.P. Kobzev, Yu.N. Kopatch, W.I. Furman, V.N. Shvetsov, Yu.V. Alekseenok, K.N. Vergel, V.M.B. Ged, D.C. Grozdov, I.I. Zinikovskaja, G.Y. Khristozova, G.S. Ahmedov, N.V. Simbirtseva, S.B. Borzakov, D.N. Grozdanov, N.A. Gundorin, M. Kulik, Zh.V. Mezentseva, I.A. Oprea, K.D. Oprea, V.R. Skoj, A.Yu. Dmitriev, 22 engineers, 4 workers	
4.	**Development of the IREN facility**	**V.N. Shvetsov**	Upgrade
	FLNP	V.G. Pjataev, E.A. Golubkov, 17 engineers, 1 worker	
	VBLHEP A.P. Sumbaev	V.F. Minashkin, V.N. Zamrij, 3 engineers	
	DLNP	I.N. Meshkov	
5.	**Development of experimental infrastructure of the IREN facility**	**V.N. Shvetsov**	Upgrade
	FLNP	A.A. Beliakov, E.V. Lychagin, V.G. Pyataev, P.V. Sedyshev, V.A. Trepalin, 15 engineers	
6.	**Modernization of EG-5 accelerator**	**A.S. Doroshkevich**	Upgrade
	FLNP	A.N. Likhachev, A.P. Kobzev, 4 engineers	
7.	**Project TANGRA**	**Yu.N. Kopatch**	Upgrade Data taking Data analysis
	FLNP	F.Aliev, N.A. Gundorin, D.N. Grozdanov, C. Hramco, I.A. Oprea, K.D. Oprea, P.V. Sedyshev, V.R. Skoi, V.N. Shvetsov, T.Yu. Tretyakova	
	VBLHEP	U.Yu. Aleksakhin, S.V. Khabarov, Yu.N. Rogov, R.A. Salmin, M.G. Sapozhnikov, V.M. Slepnev, N.I. Zamjatin, E.V. Zubarev	
	DLNP	A.V. Krasnoperov, A.B. Sadovskii, A.V. Salamatin	
	LRB	G.N. Timoshenko	

Collaboration

Country or International Organization	City	Institute or Laboratory
Albania	Tirana	UT
Australia	Melbourne	Univ.
Austria	Vienna	IAEA
	Innsbruck	Univ.
Azerbaijan	Baku	BSU
		IGG ANAS
		IRP ANAS
Belarus	Minsk	INP BSU
		ISEI BSU
		SPMRC NASB
Bulgaria	Sofia	INRNE BAS
	Plovdiv	PU
		UFT
CERN	Geneva	CERN
China	Beijing	IHEP CAS
	Xi'an	NINT
Croatia	Zagreb	Oikon IAE
		RBI
Czech Republic	Prague	CEI
		CTU
	Ostrava	UO
		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	GSI
	Dresden	HZDR
	Mainz	JGU
	Munich	TUM
	Tübingen	Univ.
Hungary	Budapest	RKK OU
India	Varanasi	BHU
Italy	Rome	ENEA

Japan	Kyoto	KSU
	Tsukuba	KEK
Kazakhstan	Nur-Sultan	ENU
	Almaty	INP
	Ust-Kamenogorsk	TRCE
Moldova	Chişinău	IC ASM
		IMB 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
	Pohang	PAL
Romania	Bucharest	IFIN-HH
		UB
	Baia Mare	TUCN-NUCBM
	Cluj-Napoca	INCDTIM
	Constanţa	NIMRD
		UOC
	Galaţi	UG
	Iaşi	UAIC
	Magurele	ISS
	Oradea	UO
	Piteşti	ICN
	Râmnicu Vâlcea	I.C.S.I.
	Sibiu	ULBS
	Târgovişte	UVT
Russia	Moscow	GIN RAS
		GPI RAS
		IKI RAS
		IPCE RAS
		ITEP
		MSU
		NRC KI
		SINP MSU
		VNIIA
	Moscow, Troitsk	INR RAS

	Borok	IBIW RAS
	Dubna	Diamant
		Dubna State Univ.
	Gatchina	NRC KI PNPI
	Grozny	CSPU
	Irkutsk	LI SB RAS
	Ivanovo	ISUCT
	Izhevsk	UdSU
	Nizhny Novgorod	IPM RAS
	Obninsk	IPPE
	Tomsk	NPI TPU
	St. Petersburg	Botanic Garden
		BIN RAS
		FIP
		Hermitage
		Ioffe Institute
		KRI
		SPSFTU
	Sevastopol	IBSS
	Tula	TSU
	Vladikavkaz	NOSU
	Voronezh	VSU
	Yekaterinburg	UrFU
Serbia	Belgrade	IPB
		Univ.
	Novi Sad	UNS
North Macedonia	Skopje	UKiM
Slovakia	Bratislava	CU
		IEE SAS
		ILE SAS
		IP SAS
Slovenia	Ljubljana	GeoSS
South Africa	Pretoria	UNISA
	Bellville	UWC
	Stellenbosch	SU
Switzerland	Villigen	PSI
Thailand	Hat Yai	PSU
Turkey	Çanakkale	ÇOMU
Ukraine	Kiev	KINR NASU
		NUK
	Berdyansk	BSPU
	Kharkov	ISMA NASU
		NSC KIPT
	Donetsk	DonIPE
	Sumy	IAP NASU

	Uzhgorod	IEP NASU
USA	Durham, NC	Duke
	Los Alamos, NM	LANL
	Oak Ridge, TN	ORNL
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: Being concluded

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 results in the current year:

Realization of scientific program:

- Determination of parameters of atomic and magnetic structure of novel bulk and nanostructured functional materials demonstrating interesting physical phenomena and being promising for technological applications in a wide range of thermodynamic parameters.
- Analysis of characteristic features of atomic and magnetic structure of complex oxides with spinel structure in a wide range of thermodynamic parameters.
- 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 spectrometers:

- Modernization of the neutron guide system of the new DN-6 diffractometer for studies of microsamples, development of high-pressure cells.
- 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 spectrometers (HRFD, RTD, DN-12, YuMO, FSD, REFLEX, REMUR, SKAT, EPSILON) 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, detector tube, 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, I.G. Genov, N.O. Golosova, S.E. Kichanov, E.V. Lukin, G.M. Mironova, A. Pawlukojc, E.P. Popov, A.V. Rutkauskas, B.N. Savenko, N.Yu. Samoylova, 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.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, 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, I. Zuba	

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, E.N. Kosyachkin, 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

FLNP: V.A. Maslova

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, B.A Abdurakhimov, E.V. Lukin, K. Nazarov, A.V. Rutkauskas, B.N. Savenko, I.Yu. Zel'

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 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, 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
		BSTU
		RI PCP BSU
Bulgaria	Sofia	ASCI Ltd
		IE BAS
		IEES BAS
		IMS BAS
		INRNE BAS
		ISSP BAS
		UCTM
Czech Republic	Prague	CTU
		BC CAS
		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
	Dresden	TU Dresden
		IKTS
	Göttingen	Univ.
	Geesthacht	GKSS
	Freiberg	TUBAF
		IMF TUBAF
	Halle	MLU
	Hamburg	DESY
	Jülich	FZJ
	Karlsruhe	KIT
	Kiel	CAU
		IFM-GEOMAR
	Konstanz	Univ.
	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.
	Matsumoto	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	BUT
		UwB
	Krakow	JU
		AGH-UST
		NINP PAS
	Lodz	UL
	Lublin	UMCS
	Otwock (Swierk)	NCBJ
	Poznan	AMU
	Siedlce	UPH
	Szczecin	WPUT

	Wroclaw	WUT
		UW
Romania	Bucharest	IFIN-HH
		INCDIE ICPE-CA
		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
	Magurele	INFLPR
		ISS
		NIMP
	Piteşti	ICN
		UPIT
	Timişoara	ICT
		LMF CCTFA
		RA TB
		UPT
		UVT
	Târgovişte	UVT
	Tulcea	DDNI
Russia	Moscow	GC RAS
		IA RAS
		IBMC
		IC RAS
		ICP RAS
		Inst. Immunology
		IEPT RAS
		IGEM RAS
		IGIC RAS
		IMET RAS
		INMI RAS
		ITEP

		IPE RAS
		ISPM RAS
		NNRU “MEPhI”
		MIET
		MITHT
		MISiS
		MSU
		NRC KI
		OKSAT NIKIET
		PIN RAS
		SINP MSU
		SC “VNIINM”
	Moscow, Troitsk	HPPI RAS
		ISAN
		INR RAS
	Belgorod	BelSU
	Chernogolovka	ISSP RAS
	Dolgoprudny	MIPT
	Dubna	Dubna State Univ.
		EI
		Lition
	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	SB BashSU
	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
		DonNUET
	Kharkov	IERT NASU
		NSC KIPT
United Kingdom	Didcot	RAL
Uzbekistan	Tashkent	INP AS RUz
Vietnam	Hanoi	IOP VAST
	Da Nang	DTU

04-4-1105-2011/2022	Priority: 1

Status: Extended

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

Leaders: A.V. Vinogradov
A.V. Belushkin
A.V. Dolgikh

Participating countries and international organizations:

Azerbaijan, Belarus, Mongolia, Poland, Romania, Russia, Spain.

Issues addressed and main goals of research:

The 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 results in the current year:

- Provision of the IBR-2 reactor operation for physics investigations.
- Check assembling, adjustment and testing of the backup movable reflector MR-3R at the FLNP test bench. Experimental investigations on determination of dynamic characteristics and parameters of vibrations of the units and structure modules at the stage of assembly and bench testing of MR-3R.
- Operation of the test stand of the cryogenic moderator CM-201. Installation of the cryogenic moderator CM-201 in the regular place and putting it into trial operation. Development of requirements specification and project documentation for the cryogenic moderator CM-203 for beamlines 2 and 3.
- Phased replacement and upgrade of the basic technological and electrical safety-related equipment of the IBR-2 facility.

List of projects:

	Project	Leader	Priority (period of realization)
1.	Construction of the complex of cryogenic moderators at the IBR-2 facility	K.A. Mukhin	1 (2014 – 2022)

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. **Provision of physics research program** — **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. **Experiments at the test stand of cryogenic moderator CM-201. Test operation of equipment of cryogenic moderator CM-201. Operation of cryogenic moderators using new cryogenic refrigerator by Linde in the regular place** — **A.A. Belyakov, K.A. Mukhin** — Realization

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

4. **Assembling of backup 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
Azerbaijan	Baku	IRP ANAS
		NNRC
Belarus	Minsk	JIPNR-Sosny NASB
Mongolia	Ulaanbaatar	IPT MAS
Poland	Krakow	AGH-UST
Romania	Bucharest	IFIN-HH
Russia	Moscow	OKSAT NIKIET
		Geliymash
		INEUM
		SYSTEMATOM
		SSDI
		ENES
Spain	Valencia	UPV

04-4-1122-2015/2020	Priority: 1

Status: Being concluded

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, 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 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 results in the current year:

- Trial operation of CM-201 and CM-202 moderators for beamlines 1, $4 \div 11$ of the IBR-2 reactor. Obtaining spectra for some beamlines during operation of CM-201 in the cryogenic mode, comparing them with spectra obtained from the thermal moderator. Automation of control over vacuum equipment of the moderators' complex. Test operation of the optical sensor designed to control the movement of pellets and count them during their pneumatic transportation to the moderator chamber and of the diaphragm flowmeter of the moderators' complex. Determination of release of radiolytic hydrogen in the CM-201 moderator chamber.

- Investigation of radiation resistance of materials at the radiation research facility. Integration of a robotic manipulator into the video surveillance and distance measurement system for remote control of handling samples by personnel working in high ionizing radiation fields.

- Creation of virtual models of spectrometers and simulation of neutron scattering experiments. Determination of configurations of existing and planned neutron instruments in order to maximize beam time efficiency.

- Completion of development and manufacturing of a horizontal/vertical cryostat with a superconducting magnet and variable temperature range of 4-300 K (PTH project), its testing and preparation for commissioning on the DN-12 diffractometer. Study of a continuous-flow cryostat based on a closed-cycle cryocooler in various operating modes. Modernization of cryostats, cryogenic and vacuum equipment of IBR-2 spectrometers (by request of instrument responsibles).

- Completion of work under the BSD project (completion of manufacturing, assembling and tuning of the first sector of the BSD detector for the HRFD diffractometer).

- Development of a detector system based on 2D PSD with a central opening for a direct beam on the REMUR spectrometer (development of technical design, purchase of components and electronic modules, manufacturing of necessary parts and components). Improvement of technologies for manufacturing gas detectors (tuning and commissioning of winding machine; purchase of materials and wire-soldering equipment, thin-film deposition system for coating components of detectors, etc.). Manufacturing and calibration of a detector to determine the absolute intensity of IBR-2 neutron beams.

- Development of electronics for 240 measuring channels for acquiring and storing data from the BSD detector of the HRFD diffractometer. Modernization of data acquisition systems on the REFLEX and GRAINS spectrometers on the basis of new MPD32-USB3 modules and De-Li-DAQ2 modules for acquiring data from position-sensitive detectors in the raw data transfer mode. Application of digitizers in data acquisition systems, as well as in the equipment of the test stand for the development and debugging of event selection algorithms for scintillation detectors.
- Installation, tuning and commissioning of CC-3U chopper controller into trial operation on the NERA spectrometer. Installation and tuning of a remote control system of choppers on the GRAINS and YuMO spectrometers. Modernization of control systems for actuators of spectrometers on IBR-2 beamlines 6a, $8 \div 11$. Installation, tuning and commissioning of a new Fourier chopper on the FSD diffractometer.
- Support and improvement of the Sonix+ software package by users' request, development of software modules for new equipment of spectrometers. Completion of translation of Sonix+ programs into Python (version 3) and transition to Qt5 graphics framework using Visual Studio 2017. Introduction of new software on the SKAT, NERA and GRAINS spectrometers. Improvement of the structure of FLNP mail service and creation of a prototype of a new mail cluster. Enhancement of capabilities of laboratory servers in connection with the changeover to a data rate of 10 Gbit/s. Reconstruction of Wi-Fi network in FLNP building 42a.

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 engineers

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

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 engineers

   LIT: V.V. Korenkov, 2 engineers

Collaboration

Country or International Organization	City	Institute or Laboratory
Argentina	Bariloche	CAB CNEA
Belarus	Minsk	BSTU
		INP BSU
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
	Cluj-Napoca	INCDTIM
	Târgovişte	UVT
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
Sweden	Lund	ESS ERIC
Switzerland	Villigen	PSI
Ukraine	Lviv	LPNU
United Kingdom	Didcot	RAL
Uzbekistan	Tashkent	INP AS RUz
		INR AS RUz

04–4-1133—2018/2020	Priority: 1

Status: Being concluded

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, 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 detection – 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 results in the current year:

- Systematic experiments on SECARS spectroscopy and intensity mapping with picosecond laser pulses.
- Measurement and detection of extremely low concentrations of organic molecules with the use of SERS and SECARS - setting up a method for microspectroscopy of single molecules.
- Comparison of SERS and SECARS spectra and intensity maps of light scattered from organic reporter molecules.
- The final stage in the synthesis of core-shell nanostructures:
  $NaYF_4$:Yb^{3+}, Er^{3+},Tm^{3+}@SiO_2 and testing their effectiveness in biomedicine.
- Studies of conformational changes in phospholipids under the influence of cholesterol and melatonin using Raman and IR spectroscopy.

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	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	K.Z. Mamatkulov, M.Ju. Vorobjeva, A.S. Marchenko	
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	M.Ju. Vorobjeva, A.S. Marchenko, S.K. Rudnikh, I.A. Morkovnikov	
4. **Revealing the influence of cholesterol and melotanin on the structure of lipid bilayer using the Raman spectroscopy method**	**G.M. Arzumanyan** **N. Kučerka**	Data taking
FLNP	K.Z. Mamatkulov, M.Ju. Vorobjeva, K.Sh. Voskanyan, A.S. Marchenko, S.K. Rudnikh	
5. **Study of spectral-structural characteristics of upconversion phosphors based on core-shell type nanostructures**	**G.M. Arzumanyan** **N. Kučerka**	Data taking
FLNP	K.Z. Mamatkulov, A.S. Marchenko, M.Ju. Vorobjeva, K.Sh. Voskanyan	
6. **Test application of core-shell nanostructured phosphors in biomedicine**	**G.M. Arzumanyan** **N. Kučerka**	Realization
FLNP	K.Z. Mamatkulov, M.Ju. Vorobjeva, A.S. Marchenko, K.Sh. Voskanyan, S.K. Rudnikh	
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 K.Z. Mamatkulov, M.Ju. Vorobjeva

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL
Belarus	Minsk	BSUIR
		SOL instruments
Bulgaria	Sofia	ISSP BAS
Cuba	Havana	InSTEC
Egypt	Cairo	EPRI
Latvia	Riga	ISSP UL
Poland	Wroclaw	UW
	Poznan	AMU
Romania	Cluj-Napoca	INCDTIM
Russia	Moscow	GPI RAS
Slovakia	Košice	UPJS
Ukraine	Donetsk	DonNU

04–4–1140–2020/2022	Priority: 1

Status: New

Development of the Conceptual Design of a New Advanced Neutron Source at JINR

Leader: V.N. Shvetsov
S.A. Kulikov

Participating countries and international organizations:

Russia, Belarus, Romania, Argentina, Czech Republic, Hungary, Germany, Sweden, France, Uzbekistan, South Africa

Issues addressed and main goals of research:

Development of the conceptual design of a new advanced neutron source at JINR.

Expected results in the current year:

- Selection of a concept for the new source.
- Publication of a "white book".
- Simulation of the first three instruments for the new source.

List of activities:

	Activity or experiment **Laboratory or other Division of JINR**	**Leaders** **Main researchers**
1.	**Scientific rationale for the creation of the new source, the "white book"**	**V.N. Shvetsov**
	FLNP	S.A.Kulikov
2.	**Development and justification of the choice of a conceptual design of a high-flux pulsed neutron source of periodic operation**	**V.N. Shvetsov**
	FLNP	S.A. Kulikov
	OKSAT NIKIET	I.T. Tretiakov
3.	**Preparatory work on the manufacturing of fuel loading/target for the new source**	**V.N. Shvetsov** **S.A. Kulikov**
	FLNP	A.V. Vinogradov, A.V.Dolgikh
	SC "VNIINM"	Yu.A.Ivanov
4.	**Development of the concept of layout of neutron moderators, extracted neutron beams and instruments**	**V.N. Shvetsov**
	FLNP	S.A. Kulikov

5. **Development of technical specifications for the design of the new source with a suite of research instruments on extracted beams** — **V.N. Shvetsov**

FLNP — S.A. Kulikov, A.V. Vinogradov

Collaboration

Country or International Organization	City	Institute or Laboratory
Argentina	Bariloche	CAB CNEA
Belarus	Minsk	BSTU
Czech Republic	Řež	NPI CAS
France	Grenoble	ILL
Germany	Berlin	HZB
	Jülich	FZJ
Hungary	Budapest	Wigner RCP
Romania	Bucharest	INCDIE ICPE-CA
Russia	Moscow	OKSAT NIKIET
		SC "VNIINM"
		NRC KI
	Moscow, Troitsk	INR RAS
	Gatchina	NRC KI PNPI
South Africa	Pretoria	UP
Sweden	Lund	ESS ERIC
Uzbekistan	Tashkent	INP AS RUz

04–4–1141–2020/2022	Priority: 1

Status: New

Development of the SOLCRYS Structural Research Laboratory at the SOLARIS National Synchrotron Radiation Centre

Leader:

N. Kučerka

Participating countries and international organizations:

Belarus, Poland, Russia, Slovak Republic, Ukraine.

Issues addressed and main goals of research:

The development of a new laboratory for structural research of new materials (catalysts, polymers, etc.), nanomaterials (nanoparticles, nanocomposites, etc.), materials under extreme conditions (superconductors, perovskites, etc.), and biomaterials (proteins, DNA, etc.) utilizing synchrotron X-rays.

Expected results in the current year:

- Development of technical infrastructure for the SOLCRYS laboratory.
- Development and design of the insertion device (superconducting wiggler or other system), which will allow obtaining synchrotron radiation in the range of 5 to 22 keV, to be used by the end stations of the SOLCRYS beamline.

List of activities:

	Activity or experiment Laboratory or other Division of JINR	Leaders Main researchers
1.	**Elaboration and development of Technical Infrastructure within a scope necessary to install and properly operate the research equipment of the SOLCRYS laboratory.**	**Kučerka N.**
2.	**Design, purchase and installation of a superconducting wiggler as a radiation source in the X-ray range with an upper photon energy at least 20 keV.**	**Kučerka N.**
3.	**Design, purchase and installation of research lines of synchrotron radiation.**	**Kuklin A.I.** **Lukin E.V.**
4.	**Design, purchase and installation of measuring stations for diffraction studies and studies of scattering at small angles.**	**Kuklin A.I.** **Lukin E.V.**
5.	**Design and assembly of control systems as well as of data acquisition and storage systems.**	**Kučerka N.** **Kuklin A.I.** **Lukin E.V.**

Collaboration

Country or International Organization	City	Institute or Laboratory
Poland	Krakow	SOLARIS
	Poznan	AMU
Russia	Novosibirsk	BINP SB RAS
Belarus	Minsk	BSU
Ukraine	Kiev	NUK
Slovakia	Bratislava	CU

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, 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 nanotechnology applications for ion beams. Upgrade of the FLNR facilities for the production of medical isotopes and the development of materials modification methods.

Expected results in the current year:

- Formation of subnanometer channels in ion-irradiated polyethylene terephthalate films using a combination of photolytic treatment and liquid extraction. Investigation of the transport properties of fabricated ion-selective membranes.
- Clarification of the role of osmotic effects occurring during etching of asymmetric track nanopores and the evaluation of the interrelation between their diode-like properties and osmotic phenomena.
- Use of transmission electron microscopy and molecular dynamic simulation for the analysis of latent tracks of swift heavy ions in polycrystalline and amorphous silicon nitride as a material for minor actinides utilization.
- Study of the structure and the electrical properties of graphene oxide modified by high-energy ion irradiation.
- Study of the structure effects and gas swelling behavior of ferritic steels for nuclear reactors by electron microscopy techniques under high-energy ion irradiation.
- Preparation and characterization of functional polymer nanofibers, including biodegradable, immobilized on the surface of metallized track membranes for membrane-sorption separation of electrolyte solutions.
- Formation, morphology and composition of superhydrophobic layers on the surface of track-etched membranes using electron-beam dispersion coating of polymers in vacuum for membrane distillation process.
- Application of X-ray fluorescence and gamma-activation analysis for assessing the environmental impact from existing industrial facilities, in particular coal-fired thermal power plants (in cooperation with Mongolia).
- Expansion of the equipment infrastructure and the adoption in labs of new physicochemical methods of research (spectroscopy of surface-enhanced Raman scattering, dynamic light scattering, measurement of thermo-stimulated currents in dielectrics) and synthesis (electrospinning) of nanostructures.
- A feasibility study for the construction of a DC-140 cyclotron.

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, I.A. Bobrikov	
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. **Project of cyclotron complex DC-140**	**G.G. Gulbekian**	Preparation
FLNR	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, V.A. Semin, V.A. Veryovochkin	
VBLHEP	A.A. Fateev, 2 pers.	

Collaboration

Country or International Organization	City	Institute or Laboratory
Belarus	Minsk	BSU
	Gomel	GSU
		MPRI NASB
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	Nur-Sultan	BA INP
		ENU
		NU
	Almaty	PhysTI
Moldova	Chişinău	IAP
		MSU
Mongolia	Ulaanbaatar	CGL
		NRC NUM
Poland	Warsaw	INCT
		WUT
	Lublin	UMCS
	Torun	UMK
Russia	Moscow	IC RAS
		ISPM RAS
		GPI RAS
		LPI RAS
		MAI
		MIEM
		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
		IFIN-HH
		UPB
	Baia Mare	TUCN-NUCBM
	Magurele	INFLPR
Serbia	Belgrade	INS “VINČA”
Slovakia	Bratislava	IEE SAS
		PF SK
South Africa	Pretoria	UP
	Bellville	UWC
	Port Elizabeth	NMU
	Stellenbosch	SU

Spain	Valencia	UV
USA	Stanford, CA	SU
	Knoxville, TN	UTK
	Oak Ridge, TN	ORNL
Vietnam	Hanoi	IOP VAST

04–9–1077–2015/2020	Priority: 1

Status: Being concluded

Research on the Biological Effects of Heavy Charged Particles of 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 effects of heavy charged particles of 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, and repair kinetics of clustered DNA double-strand breaks (DSBs) in human skin fibroblasts and mammalian CNS neurons *in vivo* and *in vitro* after exposure to heavy charged particles (HCP).
- To continue evaluating the proportion of different DNA DSB repair pathways in human fibroblasts after exposure to radiation of different quality – by immunocytochemical staining of the repair proteins RAD51 (HR), DNA PKcs (NHEJ), and Ku70.
- To study the influence of DNA synthesis inhibitors on the formation and repair of clustered DNA damage in human skin fibroblasts and in mammalian CNS neurons *in vivo* and *in vitro*.
- To continue studying regularities in DNA DSB formation and elimination in rodent brain neurons after exposure *in vivo* and *in vitro* to radiation of different quality using a primary hippocampal culture.
- To study regularities in the formation and repair of clustered DNA DSBs induced by ionizing radiation of different quality in radioresistant human U87 glioblastoma cells *in vitro*.

- To study radiation effects in laboratory animals' glial brain cells after exposure to ionizing radiation of different quality.
- To continue the multicolor FISH analysis of the action of gamma rays and accelerated protons on peripheral human blood lymphocytes.
- To continue studying regularities in the induction of structural mutations in yeast cells by radiation of different LET.
- To compare the results of a molecular and cytogenetic analysis of HPRT-mutant subclones in mammalian cells at long times after exposure to ionizing radiation of different LET.
- To continue studying the mechanisms behind the damage and recovery of retinal cell elements after radiation exposure.
- To study the modification of small laboratory animals' behavioral reactions after HCP exposure. To identify the specifics of the pathologic changes in different brain cell populations and evaluate the possibility of reducing such disorders by different pharmacological agents.
- To study pathogenesis in different mammalian tissues and organs after HCP exposure.
- To continue the computer modeling 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 the protein structures of synaptic receptors and their functional activity.
- To develop models of the impaired functional activity of neural networks of different brain regions after radiation damage.
- 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).

List of projects:

	Project	**Leader**	**Priority (period of realization)**
1.	Research on the biological effects of heavy charged particles of 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
Belarus	Minsk	IBCE NASB
		Inst. Physiology NASB
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
	Obninsk	NMRRC
	Sochi	SRI MP
Slovakia	Bratislava	CU
Vietnam	Hanoi	INPC VAST

04–9–1112–2013/2022	Priority: 1

Status: Extended

Research on Cosmic Matter on 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 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 search for and study of biofossils in meteorites and the most ancient terrestrial rocks.
- To continue the detection of fossilized microorganisms in Archaean and early Proterozoic rocks and their study 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 continue the research on the nature of the catalysts participating in the synthesis of complex prebiotic compounds from formamide.
- To complete the preparation of the 2nd volume of an illustrated atlas of microfossils in meteorites.

List of projects:

	Project	Leader	Priority (period of realization)
1.	Research on cosmic matter on 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 – 2022)

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

04–2–1132–2017/2022	Priority: 1

Status: Extended

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

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

Participating countries and international organizations:

Moldova, Czech Republic, India, Poland, Romania, Russia, South Africa

Issues addressed and main goals of research:

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

Expected 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.
- Design and construction 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.
- Continuation of research to determine forms of fibroblast cell death depending on the dose of ionizing radiation.
- Study of mechanisms of functional and neurochemical disorders in the central nervous system under the action of radiation with different linear energy transfer.
- Mastering of new methodes for evaluation of the effectiveness of the cytotoxic action of nanoparticles on tumour cells.
- Continuation of the molecular analysis of gamma- and neutron-induced intragenic structural changes in germline cells.
- Start of the sequence analysis of inherited DAN changes at the genome level of the offspring.
- Beginning of the work on the analysis of the transcriptome in somatic cells differing in radiosensitivity.

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 – 2022)
2.	RADIOGENE: Molecular genetics of radiation-induced changes at the gene, genome and transcriptome level in Drosophila melanogaster	I.D. Alexandrov	1 (2017 – 2022)

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, O.V. Belov, 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. Khosenova, I.Ye. Miller, A.G. Molokanov, K. Oancea, S.A. Pisareva, A.V. Rzyanina, K.N. Shipulin, M.A. Tseytlina	
2. **RADIOGENE: Molecular genetics of radiation-induced changes at the gene, genome and transcriptome level in Drosophila melanogaster**	**I.D. Alexandrov**	R&D
DLNP	M.V. Alexandrova, K.P. Afanasyeva, A.E. Ivanova, N.E. Kharchenko, S.V. Korablinova, L.N. Korovina, Ye.V. Kravchenko, N.V. Orlova, A.N. Rusakovich, O.P. Solodilova	

Collaboration

Country or International Organization	City	Institute or Laboratory
Czech Republic	Prague	PTC
		ADVACAM
	Řež	UJV
Moldova	Chişinău	MSU
Poland	Otwock (Swierk)	NCBJ
	Poznan	GPCC
Romania	Bucharest	IFIN-HH
Russia	Moscow	IBMP RAS
		DMS RAS
		VIGG RAS
		FMBC
	Dubna	RDH-9
	Rostov-on-Don	SFedU
South Africa	Faure	iThemba LABS

04–2–1126–2015/2020	Priority: 1

Status: Being concluded

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, Egypt, 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 basis 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. Conduct of 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 of the electron accelerator Linac–200 up to 800 MeV and creating of a research infrastructure for studies using its test beams. Use of the facility for applied research and practical training of students and PhD students – future engineers from the JINR member states.
Research in condensed matter physics using the method of positron annihilation spectroscopy (PAS). Development of a PAS method based on the beam of monochromatic positrons, and 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 results in the current year:

- Publication of the results from the GaAsPix system for radiation background monitoring in ATLAS.
- Study of the radiation hardness of GaAs:Fe.
- Measurement of the response of Timepix detectors and development of the particle identification method.
- Upgrade of the existing stations for measuring properties of semiconductor detectors.
- Construction of a 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 fabrication of detectors based on the Medipix4 chip.
- Development of software for modeling of Medipix Pixel detector for spectral microtomography, including improvement of computational algorithms.
- CT scan of biosamples in cooperation with medica experts.
- 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 geophysicists.
- Upgrade of the vacuum system at A01-A04 stations of Linac-200.

- Development of the ACS.
- Start of practice at the "training" beam
- Construction of the positron lifetime system based on the variable-energy positron beam. Implementation of the reactive ion etching system for material investigations with a positron beam. Positron annihilation stydies of materials used in nuclear applications.
- Experiments with the Active Target (GDH).
- R&D of the SPECT method with Medipix detectors.
- Construction a setup for measurements with electron testbeams.
- Commissioning of the first stage of the linear electron accelerator.

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.	Development of experimental techniques and applied research with slow monochromatic positron beams (PAS)	A.G. Kobets P. Horodek Scientific leader: I.N. Meshkov	1 (2016 – 2020)
3.	GDH&SPASCHARM	Yu. Usov A. Kovalik	1 (2011 – 2022)

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, D.A. Kozhevnikov, V.G. Kruchonok, N.K. Kuznetsov, A.V. Lapkin, A. Leyva, A.A. Nozdrin, V.N. Pavlov, S.Yu. Porokhovoy, D.D. Rostorguev, 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 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, 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
4. **Construction of the setup for measurements with electron testbeams in 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. Davydov, A.S. Dyatlov, D.V. Demin, N.I. Garanzha, I.N. Garanzha, K.I. Gritsay, V.V. Glagolev, V.D. Korovyakov, A.V. Krasnoperov, A.A. Nozdrin, I.N. Polyakova, S.Yu. Porokhovoy, Ya.A. Samofalova, A.V. Skrypnik, A.G. Sorokin, V.G. Shabratov, D.S. Shokin, R.V. Timonin, A.N. Trifonov, 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
CERN	Geneva	CERN
Croatia	Zagreb	RBI
Cuba	Havana	CEADEN
Czech Republic	Prague	CTU
Egypt	New Borg El-Arab	E-JUST
	Cairo	NRRA
Germany	Hamburg	DESY
	Mainz	JGU
	Bonn	UniBonn
	Giessen	JLU
	Zeuthen	DESY
Italy	Pavia	INFN
New Zealand	Christchurch	UC
Poland	Krakow	NINP PAS
Romania	Magurele	ISS
Russia	Moscow	MSU
		ITEP
	Moscow, Troitsk	INR RAS
	Arkhangelsk	NArFU

	Dubna	Dubna State Univ.
	St. Petersburg	SPbSPU
	Tomsk	TSU
South Africa	Faure	iThemba LABS
Switzerland	Basel	Uni Basel
Ukraine	Kharkov	IERT NASU
		ISMA NASU
United Kingdom	Glasgow	U of G
	Edinburgh	Univ.
USA	Seattle, WA	UW

Networking, computing, computational physics (05)

05–6–1118–2014/2023	Priority: 1

Status: Extended

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, 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 develop 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 Seven-Year Plan for the development of JINR. A particular direction within the theme is the development of the JINR LIT Multifunctional Information and Computing Complex (MICC) presented as a Project.

Expected results in the current year:

- Provision of the reliable operation of the JINR local network, namely the NICA megaproject transport network (400 Gbps); the LIT mesh network (100 Gbps); the backbone network (2x100 Gbps); the Wi-Fi network of the JINR campus using deep signal penetration technologies. Modernization of the internet-exchange node Dubna-IX. Development of the SSO authorization service. Work on updating the level of information security, namely the organization of the DPI gateway, i.e. a system service of deep analysis of data packages; the adaption of the 6-layered structure of information security management of the JINR network.

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

  Building up the MICC basic grid component, i.e. the Tier1 center of the CMS experiment at JINR: processor capacities up to 200 kHS06, dCache storage systems on disks up to 8.8 PB and tape storage up to 25 PB.

  Expansion of the computing resources and data storage systems as part of the Tier2/CICC integral component, namely processor capacities up to 110 kHS06 and disk storages up to 5.5 PB.

  Expansion of the capacity of the general distributed data storage system on the basis of the EOS file system at the JINR MICC up to 10 PB.

  Enlargement of the computing part of the MICC cloud component to expand the range of services and the number of resources provided to users up to 2000 CPU cores and 10 TB of RAM. Increasing the total volume of cloud storage based on ceph up to 1.5 PB. Expansion of the capacity of the JINR cloud due to resources acquired by the experiments Baikal-GVD, JUNO, NOvA and their support. Development of the distributed information and computing platform based on DIRAC integrating cloud resources of the organizations of the JINR Member States.

  Development of the computing resources of the "Govorun" supercomputer to meet the needs of users from JINR and its Member States.

  Development of the data processing flow management system: the analysis of deployed services and solutions, the choice of load and data management systems, the refinement of components, the integration with the authentication system, the elaboration of an authorization system, the development of an information system, the stage-by-stage integration with the MICC resources.

Introduction of control parameters of the external engineering infrastructure into the MICC monitoring system: diesel generators, cooling towers, external elements of the cooling system. Work on expanding the monitoring system by including new nodes of the computing infrastructure of Tier1, Tier2, CICC and the "Govorun" supercomputer.

- Development and maintenance of the electronic document system EDS "Dubna", the project management system APT EVM for NICA, the systems ADB2, ISS, "Document Base", HR LHEP at the request of end users and the recommendations of the coordination group on the development of databases, electronic document management and information security, with the concept of the cloud SaaS platform of a unified administrative and business information system. Development and commissioning of the JINR Scientific Attestation Information System (SAIS).

  Work on the transfer from 1C MEM to a new software product 1C ERP 2.4. Creation of a mechanism for the transparent integration of the systems 1C MEM and ERP 2.4. Completion of the project of transferring the personnel management system to the configuration 1C "Corporate salary and personnel management". Work on the current maintenance, system refinement and user support. Creation of mobile systems for themes management. Continuation of works on the automation of self-supporting subdivisions. Increasing the performance and reliability of the system by optimizing the code, analyzing long requests, arising locks in the database and by increasing the performance of servers and reallocating the functionality performed on them.

  Continuation of works on upgrading the information system based on the Invenio JOIN2 platform: the unification of metadata formats; regular updating of the software platform; the development of the functionality of the JOIN2 software platform; support of collections "Authorities".

  Transition to modern software development tools including free software (Intel Parallel Studio, GNU Compiler Collection) for creating libraries of JINRLIB programs and CERNLIB mathematical programs (MATHLIB).

  Development and maintenance of central information servers and portals for information support and software for LIT and JINR activities. Maintenance of VisitCentre websites, PEPAN and PEPAN Letters journals.

  Providing users with modern IT solutions and services in the field of high performance computing, including the development of an ecosystem for machine and deep learning, Big data analysis for solving problems of fast recognition of multiple tracks in particle physics experiments. Development of the HLIT-VDI service for calculations as part of application packages with an advanced graphics interface such as Mathematica, Matlab, COMSOL Multiphysics, FLUKA, etc. Introduction and development of the "My Account" service providing platform users with information on work in the system, platform resource usage statistics, etc.

- Organizing and conducting regular courses on modern IT technologies including special courses from leading software developers for both the Institute staff and students and young scientists from the JINR Member States within practices organized by the UC and conferences and schools organized by JINR. Organizing specialized courses on training IT specialists for solving problems related to the processing and analysis of data for megascience experiments, including the NICA project.

List of projects:

	Project	Leader	Priority (period of realization)
1.	MICC	V.V. Korenkov	1 (2017 – 2023)

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, 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, E.N. Grafova, 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, A.N. Moshkin
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	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, M.S. Plyashkevich, L.V. Popkova, A.V. Prikhodko, V.M. Pushkina, E.Yu. Razinkova, 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 the system for training and retraining of IT specialists based on the JINR MICC and its educational components**

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
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	BSTU
		INP BSU
		JIPNR-Sosny NASB
	Gomel	GSTU
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	Nur-Sultan	BA INP
		NU
	Almaty	INP
Moldova	Chişinău	IMCS

		IAP
		RENAM
Mongolia	Ulaanbaatar	NUM
Poland	Krakow	CYFRONET
Romania	Bucharest	IFIN-HH
	Cluj-Napoca	INCDTIM
	Magurele	IFA
Russia	Moscow	FRC IM RAS
		IITP RAS
		ISP RAS
		ITEP
		KIAM RAS
		MPEI
		MSU
		MSK-IX
		NRC KI
		RCC MSU
		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	ITMO Univ.
		CC SPbSU
		ITMO Univ.
		FIP
		SPbSU
		SPbSPU
Slovakia	Košice	IEP SAS
	Prešov	PU
South Africa	Cape Town	UCT
Sweden	Lund	LU
Taiwan	Taipei	ASGCCA
Ukraine	Kiev	BITP NASU
	Kharkov	NSC KIPT

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

05–6–1119–2014/2023	Priority: 1
	Status: Extended

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

Leaders: Gh. Adam
P.V. Zrelov

Deputy: J. Buša
O. Chuluunbaatar

Participating countries and international organizations:

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

Issues addressed and main goals of research:

Carrying out paramount advanced research in computational mathematics and 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 physics studies. This subject area includes a wide spectrum of investigations approved for completion in JINR within the seven year period 2017–2023 in high energy physics, nuclear physics, physics of condensed matter and of nanostructures, biophysics, information technologies, the solution of which is inseparable from the use of computing. Such subject matters of the outmost importance in JINR are the NICA project, the neutrino program, the superheavy and exotic nuclei physics, the neutron based investigations. The needed numerical or symbolic-numerical computing will be done on the Multifunctional Information and Computing Complex (MICC), primarily the HybriLIT heterogeneous computing platform which involves the training and test cluster HybriLIT and the "Govorun" supercomputer and the emerging Big Data distributed infrastructure. The research teams include both experienced scientists with outstanding scientific achievements and enthusiastic young scientists and engineers. The requested financing will cover salaries, participations in scientific conferences, scientific visits and the acquisition of a minimal number of personal computers and licenses, within the approved resources for LIT-JINR. A distinctive feature of this research is the close cooperation of the Laboratory of Information Technologies (LIT) with research groups from all JINR laboratories and Member State institutions.

Expected results in the current year:

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

  Support for 3D multi-physical simulations using the COMSOL Multiphysics package for development of a superconducting proton therapy cyclotron in Dubna. Analysis of the measured magnetic field maps, calculations of the beam dynamics as well as of the influence of additional elements on the distribution of the magnetic field.

  Development of methods and algorithms for efficient highly accurate three-dimensional modeling of magnets and computations targeted to the creation of superconducting cyclotrons for proton therapy, in collaboration with DLNP.

  Generalization of Nambu – Jona-Lasinio – Polyakov model for the numerical description of properties of nuclear matter at NICA energies.

  Development of new molecular dynamics algorithms aimed at increasing accuracy and significantly reducing the computing time.

  Development of models for numerical studies of long-range structural changes of materials under heavy ion and nanocluster irradiation.

  Numerical modeling of ablation at material surfaces under the action of ultrashort laser pulses.

Development of numerical methods for describing equilibrium and nonequilibrium properties of mesoscopic systems of trapped atoms.

Numerical investigation of nuclear-physical processes within microscopic models, including reactions with light exotic nuclei.

Modeling neutrino-induced electromagnetic cascades at extremely high energies.

Development of methods for modeling the reflection of neutrons from layered nanostructures. Studies of magnetic films as structures consisting of vector micro-objects.

Study the role of spinor field in the evolution of the Universe (for minimal and non-minimal coupling) and in the formation of black holes and wormholes.

Maintenance of SAS primary processing program for YuMO spectrometer; development of a program for position sensitive detectors (isotropic and anisotropic scattering cases).

Step-by-step creation of an alert system for the BAIKAL project of DLNP.

Development of an extrapolation method of the sixth order with the aim at improving the algorithm efficiency for the numerical solution of a wide range of tasks.

Development of methods and algorithms for processing and analysis of the neutron noise of the IBR-2M reactor.

Multistage multiscale approach to the Bayesian automatic adaptive quadrature.

Development of algorithms for the numerical simulation of the evolution of a liquid crystal in a pulsed electric field, as well as under the influence of an orienting structured surface.

Simulation of peculiarities of the absorption-emission and photon density of states of a cholesterol liquid crystal with isotropic defect inside.

Transport approach based modeling of heavy-ion fragmentation reactions and comparison with experimental data.

- Within the Geant4 package: modeling interactions and application in various experiments (PANDA, NICA/MPD, NICA/SPD).

  Development of software support, processing and analysis of data in NUCLEON experiment.

  Software support for the BM@N experiment: development and implementation of algorithms for modeling, processing and analysis of data for the BM@N track system consisting of gas and semiconductor detectors with microstrip information acquisition (GEM, SILICON, CSC) and their subsequent integration into the BMNRoot.

  Development and refinement of the DQGSM model by comparison with experimental data of the BM@N.

  The MPD experiment: participation in the realization of a laser calibration system for detector alignment, monitoring drift velocity and for taking electric field distortion into account inside the Time-Projection Chamber (TPC) of the MPD central barrel.

  Further development of statistical methods for the analysis of experimental data under small statistics and incomplete observation of the studied processes.

  Development of batch processing of neutron diffraction spectra measured in real-time in situ mode (HRFD at IBR-2, FLNP).

  Software support of ATLAS experiment: development and maintenance of configuration and management of ATLAS TDAQ and of the EventIndex project

  Software support of CMS experiment: development, testing and implementation into the official CMS release of algorithms for the separation of overlapping signals and for building track segments in cathode strip chambers (CSC).

  The CBM experiment: development of a method for signal event selection in the CBM experiment based on a $J/\psi \to \mu^+\mu^-$ trigger. Adaptation of the ω_n^k criterion for the selection of doubly charged particles using the STS detector. Development of methods for the selection of rare decays associated with the hypernuclei.

  Improvement of the geometry database for the problems of the CBM experiment and the NICA project.

Approximation of the Internet traffic measurements in the trunk channel with the sum of log-normal distributions.

Analysis of nanostructure and properties of vesicular systems of phospholipids using the small-angle scattering data in the framework of the separated form factors model.

Massive calculations of electrostatic potentials of Zn-transcription factors with the aim at determining the nature of their interaction with the operator DNA.

- Development of ML/DL-based algorithms, including algorithms based on recurrent and convolutional neural networks with deep learning, for the rapid recognition of multiple tracks in particle physics experiments, including the NICA megaproject and the neutrino program.

  Development of algorithms based on the neural network approach for analysis and classification of medical and biological data and for forecasting the status of the environment.

  Parallelization of the most time-consuming functions using OpenMP, MPI, CUDA/OpenCL tools for modeling and reconstructing events in NICA experiments.

  Development of mathematical methods based on deep learning neural network approach for the determination of fine structures in the distribution of nuclear reaction products by mass and energy.

  Development and implementation of FEM solution of complex nonlinear magnetostatic problems within the COMSOL Multiphysics package.

  Parallel software on heterogeneous computing platforms for high performance numerical simulation of complex physical processes (Josephson junctions, localized states in condensed media, gas-hydrodynamic processes in porous media).

  Numerical study of multidimensional models based on evolutionary equations.

  Parallel algorithms for solving equations of motion of the molecular dynamics and equations of continuous media.

  Study of the possibility of increasing the performance of data analysis in ROOT through the use of graphics processors, comparative analysis of parallelization using PROOF and OpenCL (for applications in NICA project).

  Parallel implementation of large scale random matrices diagonalization.

  Parallel algorithms and codes for the solution of non-standard problems of magnetostatics.

  Solving optimization problems aimed at getting best parameters of superdense nuclear matter models in the simulation of heavy ion collisions and in astrophysical applications.

  Development of LDPC-like efficient decoding algorithms based on a genetic approach.

  Development of finite element method based computational schemes for the description of the quadrupole oscillations of the collective model of the nucleus.

  Development of computational schemes for the triangular three-center Coulomb problem and application to the H_3^+ molecule ion and H_2O molecule.

  Rebuilding mathematical packages entering the JINRLIB and CERNLIB (MATHLIB) libraries using modern software development tools, including open source (Intel Parallel Studio, GNU Compiler Collection).

  Development of the concept of a scalable software-analytical platform for the collection, storage and processing of results for the MPD experiment within the Big Data approach.

  Development of approaches for simulation, reconstruction and data processing of experiments on the basis of Big data Analytics for hybrid systems; use of new mathematical methods such as DQC (Dynamic Quantum Clustering), etc.

  Application of machine learning and artificial intelligence techniques for the optimization of the functioning of distributed computing for physical experiments; use of new mathematical methods such as Complex Networks, etc.

  Creation of a prototype system for intelligent monitoring of distributed computing systems based on the Big Data Analytics platform using streaming data and time series analysis methods.

- Modeling intelligence networks performing operations based on quantum decision theory; numerical analysis of models of artificial intelligence.

  Construction of an involutive monomial division providing compactness of the canonical involutive form.

  Development of an algorithm for reduction of systems of nonlinear algebraic equations to compact involutive form.

  HybriLIT GPU implementation of an algorithm for reduction of polynomial algebraic systems to canonical involutive form.

  Development of algorithms and programs to study multipartite quantum systems with spatial structure.

  Choice and analysis of a model of artificial neural network admitting implementation of the track reconstruction problem on existing adiabatic quantum computers.

  Definition of the basic elements for a quantum algorithm for the study of phase transitions in lattice QCD models at finite density.

  Computation of quasi-probability distributions for two qubit system.

  Computation of conditional probabilities of qubit state separability for non-negative Wigner distributions.

  Development of Lindblad equation for open relativistic systems based on the Bogolyubov equations for the state vector in relativistic quantum field theory.

  Embedding the FORM system module of field-theoretical calculations in high-energy physics into the Axiom system of computer algebra.

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** **J. Buša** **I.V. Puzynin**
LIT	S. Adam,R. Akhat, P.G. Akishin, I.V. Amirkhanov, E.A. Ayrjan, A.S. Ayriyan, I.V. Barashenkov, M.V. Bashashin, A.A. Bogolubskaya, I.L. Bogolubsky, A.M. Chervyakov, N.D. Dikusar, H. Grigorian, M. Kakenov, Yu.L. Kalinovsky, T.V. Karamysheva, M. Kakenov, D.S. Kulyabov, N.A. Kutovskyi, K.V. Lukyanov, N.V. Makhaldiani, T.I. Mikhailova, E.G. Nikonov, K. Oganesyan, T.P. Puzynina, B. Saha, N.R. Sarkar, I. Sarkhadov, Z.A. Sharipov, N.Yu. Shirikova, A.G. Soloviev, T.M. Solovieva, Yu.B. Starchenko, L.A. Siurakshina, Z.K. Tukhliev, A.V. Volokhova, O.O. Voskresenskaya, A. Wojczechowski, R.M. Yamaleev, E.P. Yukalova, E.V. Zemlyanaya, E.I. Zhabitskaya
VBLHEP	A.Yu. Boytsov, E.E. Donets, S. Gevorkyan, H.G. Khodzhibagiyan, V.A. Nikitin
BLTP	D.B. Blashke, V.V. Braguta, D.E. Castilio Alvares, A.V. Friesen, M. Hnatic, A.S. Hvorostuhin, E.-M. Ilgenfritz, V.K. Lukyanov, K.A. Maslov, L.A. Sevastianov, V.D. Toneev, V.V.Voronov, D.N. Voskresensky, V.I. Yukalov, V.Yu. Yushankhai
FLNR	M.K. Kochnev, S.M. Lukyanov, A. Oleinichak, Yu.E. Penionzhkevich, R.A. Rymzhanov, V.A. Skuratov
FLNP	E.B. Askerov, A.V. Belushkin, A.I. Kuklin, A.I. Ivankov, Yu.N. Pepelyshev

	DLNP	L.G. Afanasiev, I.A. Belolaptikov, G.A. Karamysheva, O. Karamyshev, I.N. Kiyan, B.A. Shaibonov, G.D. Shirkov
2. **Software complexes and mathematical methods for processing and analysis of experimental data**		**P.V. Zrelov** **V.V. Ivanov**
	LIT	E.P. Akishina, E.I. Aleksandrov, I.N. Aleksandrov, D.A. Baranov, M.V. Bashashin, S. Belogurov, O.Yu. Derenovskaya, I.A. Filozova, A.A. Kazakov, A.I. Kazymov, B.F. Kostenko, P.I. Kisel, G.E. Kozlov, L.Yu. Kruglova, M.A. Mineev, G.J. Musulmanbekov, A.V. Nechaevsky, G.A. Ososkov, E.V. Ovcharenko, V.V. Palichik, D.I. Pryakhina, V.S. Rikhvitsky, I. Satyshev, T.F. Sapozhnikova, V.N. Shigaev, S.K.Slepnyov, A.N. Sosnin, A.V. Uzhinsky, V.V. Uzhinsky, N.N. Voitishin, A.V. Volokhova, A.V. Yakovlev, E.V. Zemlyanaya, E.I. Zhabitskaya, V.B. Zlokazov
	VBLHEP	B.V. Batyunya, A.V. Bychkov, A.S. Galoyan, S.R. Gevorkyan, K.V. Gertsenberger, M.N. Kapishin, A.O. Kechechyan, V.P. Ladygin, V. Lenivenko, A.I. Malakhov, S.P. Merts, S.A. Movchan, S.V. Razin, O.V. Rogachevsky, V.N. Zhezher, M.A. Patsyuk
	BLTP	V.D. Toneev
	FLNR	A.G. Artukh, B. Erdemchimeg, A.S. Fomichev, Yu.E. Penionzhkevich, Yu.V. Pyatkov, Yu.M. Sereda, Yu.G. Sobolev, Yu.S. Tsyganov, V.K. Utenkov
	FLNP	A.M. Balagurov, I.A. Bobrikov, M.A. Kiselev, D.P. Kozlenko, M.V. Frontasyeva
	DLNP	I.V. Bednyakov, V.A. Bednyakov, A.G. Olshevsky, L.G. Tkachev, A.S. Zhemchugov
3. **Numerical methods, algorithms and software for multicore and hybrid architectures and Big Data analytics**		**Gh. Adam** **O. Chuluunbaatar** **P.V. Zrelov** **V.V. Korenkov** **O.I. Streltsova**
	LIT	E.I. Aleksandrov, A.S. Ayriyan, E.A. Ayrjan, M.V. Bashashin, S.D. Belov, D.V. Belyakov, J. Busa, Jr., A.M. Chervyakov, I.A. Filozova, A.A. Gusev, I.S. Kadochnikov, M.A. Matveev, I.S. Pelevanyuk, D.V. Podgainy, R.V. Polyakova, L.V. Popkova, T.P. Puzynina, A.A. Sapozhnikov, T.F. Sapozhnikova, N.R. Sarkar, I. Sarkhadov, R.N. Semyonov, S.I. Serdyukova, Z.A. Sharipov, A.G. Soloviev, T.M. Solovieva, Z.K. Tukhliev, N.N. Voytishin, A.V. Volokhova, O.I. Yuldashev, M.B. Yuldasheva, E.V. Zemlyanaya, E.I. Zhabitskaya, M.I. Zuev
	LIT-MICC	V.V. Mitsyn, T.A. Strizh
	FLNR	P.Yu. Apel, S.V. Mitrofanov, V.A. Skuratov
	BLTP	P.M. Krassovitskiy, R.G. Nazmitdinov, Yu.V. Popov, Yu.M. Shukrinov, S.I. Vinitsky

VBLHEP	K.V. Gertsenberger, A.D. Kovalenko, A.A. Moshkin, E.E. Perepelkin, O.V. Rogachevsky, V.V. Voronyuk
DLNP	V.A. Bednyakov, D.V. Naumov, A.G. Olshevskiy, O. Samoilov, E.A. Yakushev
FLNP	V.V. Novitsky + 3 pers

4. **Methods, algorithms and software of computer algebra and quantum computing** — **V.P. Gerdt**

LIT	N. Abbasly, V. Abgaryan, A.A. Bogolubskaya, A.M. Khvedelidze, V.V. Kornyak, E.A. Kotkova, A.M. Raportirenko, I.A. Rogozhin, K.K. Sharma, O.V. Tarasov, A.G. Torosyan, D.A. Yanovich, E.P. Yukalova
BLTP	A.V. Czhizhov, P. Fiziev, A.I. Titov, V.I. Yukalov
VBLHEP	O.V. Rogachevsky
FLNR	B.N. Gikal

Collaboration

Country or International Organization	City	Institute or Laboratory
Armenia	Yerevan	Foundation ANSL
		IIAP NAS RA
		RAU
		YSU
Australia	Sydney	Univ.
Azerbaijan	Baku	IP ANAS
Belarus	Minsk	IM NASB
		BSTU
Belgium	Brussels	ULB
	Louvain-la-Neuve	UCL
	Liege	ULg
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	Hangzhou	ZJU
	Hefei	IPP CAS
Czech Republic	Prague	CTU
France	Nancy	UL
	Nantes	SUBATECH
Georgia	Tbilisi	GTU

		TSU
		UG
		RMI TSU
Germany	Bonn	UniBonn
	Darmstadt	GSI
	Dresden	HZDR
		IFW
	Frankfurt/Main	Univ.
	Freiberg	TUBAF
	Giessen	JLU
	Hamburg	Univ.
	Jena	Univ.
	Kassel	Uni Kassel
	Karlsruhe	KIT
	Marburg	Univ.
	Munich	LMU
	Rostock	Univ.
	Wuppertal	UW
Greece	Thessaloniki	AUTH
Italy	Bari	UniBa
	Turin	INFN
	Catania	INFN LNS
	Frascati	INFN LNF
Israel	Tel Aviv	TAU
Japan	Osaka	Kansai Univ.
	Saitama	SU
Kazakhstan	Almaty	INP
Moldova	Chişinău	IAP
Mongolia	Ulaanbaatar	IPT MAS
		NUM
Poland	Krakow	NINP PAS
	Lublin	UMCS
	Otwock (Swierk)	NCBJ
	Warsaw	WUT
	Wroclaw	UW
Portugal	Lisbon	UL
Romania	Bucharest	IFIN-HH
		UB
	Cluj-Napoca	INCDTIM
	Magurele	ELI-NP
		IFA
		ISS
	Timişoara	UVT
Russia	Moscow	GPI RAS
		KIAM RAS

		IPMech RAS
		ICS RAS
		ITEP
		MRSU
		MSU
		RCC MSU
		NNRU "MEPhI"
		PFUR
		VIGG RAS
	Moscow, Troitsk	INR RAS
	Dubna	Dubna State Univ.
	Gatchina	NRC KI PNPI
	Novosibirsk	BINP SB RAS
	Perm	PSNRU
	Protvino	IHEP
	Puschino	IMPB RAS
		ITEB RAS
		IPR RAS
	Saratov	SSU
	St. Petersburg	NIIEFA
	Tomsk	TSU
	Tver	TvSU
Slovakia	Košice	IEP SAS
		UPJS
		TUKE
	Prešov	PU
	Banska Bistrica	UMB
South Africa	Cape Town	UCT
	Pretoria	UP
	Stellenbosch	SU
Switzerland	Zurich	ETH
Tajikistan	Dushanbe	PHTI ASRT
		TNU
	Khujand	KSU
USA	Davis, CA	UCDavis
	Los Angeles, CA	UCLA
	Madison, WI	UW-Madison
	La Jolla, CA	UCSD
	Lemont, IL	ANL
	Stanford, CA	SU
Vietnam	Hanoi	VNU

05–8–1037–2001/2024	Priority: 1

Status: Extended

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 results in the current year:

- Improvement of the organization and coordination of JINR scientific research work.
- Analysis of the results of JINR activities for 2019 in the main research areas.
- Inplementation of the 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 2021. Identification of JINR's priority research directions for 2021.
- Development of JINR's grantmaking activities and participation in special-purpose programmes for financing scientific research in 2020.
- Preparation of analytical materials for ministries and agencies.
- Development and promotion of JINR's information resources on the Internet. Support of the system of accounting of protocols on scientific and technological cooperation.
- Promotion of realization of JINR's right to independently confer academic degrees. Support of the operation of JINR's dissertational councils.
- Preparation for the publication of the JINR Annual Report for 2019. 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 fields 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 memberships 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.	**Preparation for the publication of the Topical Plan for 2021**	**A.S. Sorin** **O.V. Belov**
	SOD	N.I. Sissakian, N.A. Boklagova, D.S. Korobov
2.	**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
	STD AMIS	V.F. Borisovsky
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, D.S. Korobov
5.	**Support for the operation of JINR's 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, O.K. Kronshtadtov, D.S. Korobov
	STD AMIS	V.F. Borisovsky
	SID	B.M. Starchenko
	Editorial office of the weekly newspaper "Dubna: science, community, progress"	E.M. Molchanov
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, S.N. Kruglova
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: In-progress

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, Kazakhstan, Moldova, Mongolia, Poland, Romania, Russia, Serbia, Slovakia, South Africa, Ukraine, USA, Vietnam.

Issues addressed and main goals of research:

Development and implementation of the human resources training programmes at JINR aimed at further employment of the trainees as scientific and engineering specialists of the Institute; creation of appropriate conditions for students and PhD students from universities of the Member States to enable them to work on their qualification theses based on the research conducted in the laboratories of the Institute; support of the educational process for students of the JINR-based departments at universities of the Russian Federation, as well as development of network training programmes; oraganisation and running of international student practices and schools for young people from the JINR Member States; training of students, PhD students, and interns on the basis of cooperation agreements with universities of the JINR Member States and international organisations; building and maintenance of laboratory environment intended for hands-on training in accelerator physics and nuclear physics; support and development of a system of training courses aimed at gaining or improving professional skills and qualifications of JINR technical and engineering personnel; development of the JINR outreach programme and promotion of modern science achievements among school students and teachers, organisation of excursions and online tours of the JINR basic facilities; further development of the JINR educational portal (edu.jinr.ru), development of a set of e-learning courses on the main areas of research conducted at JINR in the official languages of the Institute and by its leading experts; development of virtual and real laboratories allowing students to be trained using modern experimental equipment; participation in science festivals and exhibitions promoting JINR.

Expected major results in the current year:

- Support and supervision of the educational process at the JINR-based departments of Russian universities.
- Support of the system of assigning young researchers to JINR laboratories for preparation of their PhD theses without mastering the academic programmes of the PhD course.
- Organisation and running of the International Student Practices in JINR Fields of Research for students of JINR Member States' universities.
- Expansion of the scientific scope of research projects of the Summer Student Programme at JINR and increasing the number of participants in this programme.
- Development of the training facilities, including test-benches and sets of laboratory works, for the needs and tasks of the UC-based Scientific-Engineering Group.
- Organisation of JINR-based internship for participants in the International School of Engineering of Dubna State University.
- Organisation of scientific schools for physics teachers from the Institute Member States at CERN and JINR.
- Launch of virtual tours of JINR and video-conferences with educational institutions of the Member States.

- Development of a set of e-learning cources in nuclear physics, particle physics, condensed matter physics, and JINR basic facilities.
- Promotion of modern educational resources in the JINR Member States.
- Organisation of JINR participation in the Science Festival "NAUKA 0+ 2020" on the basis of Russian universities.
- Development of the language courses programme aimed at teaching Russian, English, French, and German to JINR personnel.
- Participation of JINR in an interdisciplinary social educational project "Summer School 2020".

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	A.Yu. Verkheev, A.G. Olshevskiy, V.V.Glagolev
BLTP D.I. Kazakov A.P. Isaev A.B. Arbuzov	A.V. Gladyshev, Yu.M. Shukrinov
FLNP V.N. Shvetsov E.V. Lychagin O.A. Culikov	D.P. Kozlenko, A.M. Balagurov, A.V. Belushkin
VBLHEP N.A. Strokovsky, V.D. Kekelidze D.V. Peshekhonov	V.A. Nikitin, S.S. Shimansky, N.I. Zimin
FLNR S.N. Dmitriev A.V. Karpov A.G. Popeko	S.I. Sidorchuk S.G. Belogurov
LIT V.V. Korenkov T.A. Strizh D.V. Podgaynyi	V.P. Gerdt, I.S. Pelevanyuk
LRB E.A. Krasavin I.V. Koshlan	G.N. Timoshenko
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, N.I. Vorontsova, E.I. Golubeva, R.V. Klygina, M.P. Osmachko, Yu.D. Orlova, N.E. Sidorov, G.D. Semchukov, G.A. Yarygin
3. Outreach and JINR promotion	**S.Z. Pakuliak** **A.A. Suzhevich**
DLNP	N.V. Anfimov, A.Yu. Verkheev, Ch.T. Kullenberg, M.V. Fomina, M.V. Shirchenko
BLTP	A.V. Frizen
FLNP	C. Khramko
VBLHEP	A.S. Bogomolova, D.K. Dryablov, D.I. Klimansky, Ch. Roslon
FLNR	K.B. Gikal, A.A. Voinov
LIT	I.S. Pelevanyuk, Sh.G. Torosyan
LRB	T.S. Bulanova, I.A. Kolesnikova, Yu.S. Severyukhin
Universal JINR 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	INP BSU
		ISEI BSU
		BSTU
		BSU
		ME RB
	Gomel	GSU
Bulgaria	Sofia	INRNE BAS
		NRA
		SU
	Blagoevgrad	SWU
CERN	Geneva	CERN
Cuba	Havana	ASC
Czech Republic	Prague	CU
		CTU
Kazakhstan	Nur-Sultan	ENU
	Almaty	KazNU

	Ust-Kamenogorsk	EKSU
Moldova	Chişinău	ASM
Mongolia	Ulaanbaatar	NUM
		MNUE
Poland	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
	Kazan	KFU
	Kostroma	KSU
	Krasnodar	KSU
	St. Petersburg	SPbSU
	Smolensk	SSU
	Tomsk	TPU
	Tula	TSU
	Tver	TvSU
	Voronezh	VSU
	Vladikavkaz	NOSU
	Yakutsk	NEFU
Slovakia	Bratislava	CU
	Košice	UPJS
		STM
South Africa	Faure	iThemba LABS
	Stellenbosch	SU
Ukraine	Kiev	BITP NASU
		NUK
USA	Upton, NY	BNL
Cuba	Havana	ASC
Serbia	Belgrade	INS "VINČA"
	Novi Sad	UNS
	Sremska Kamenica	Educons Univ.
Vietnam	Hanoi	IOP VAST
	Da Lat	DLU
		NRI

Alphabetic List of Collaborators

Albania

Tirana

UT (University of Tirana | http://www.unitir.edu.al/), 131

Argentina

Bariloche

CAB CNEA (Bariloche atomic Centre National Atomic Energy Commission | http://www.cab.cnea.gov.ar/), 140, 149, 155

Armenia

Garni

GGO (Garni Geophysical Observatory), 90

Gyumri

IGES NAS RA (Institute of Geophysics and Engineering Seismology named after A. Nazarov of the National Academy of Sciences of the Republic of Armenia | http://www.ipr.sci.am/), 90

Yerevan

Foundation ANSL (A.I.Alikhanian National Science Laboratory (Yerevan Physics Institute - YerPHI) Foundation | http://www.yerphi.am/), 12, 24, 30, 42, 64, 84, 98, 104, 153, 187

IIAP NAS RA (Institute for Informatics and Automation Problems of the National Academy of Sciences of the Republic of Armenia | http://iiap.sci.am/), 24, 179, 187

RAU (Russian-Armenian University | http://www.rau.am/), 12, 18, 187

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

YSU (Yerevan State University | http://ysu.am/), 18, 24, 29, 33, 84, 98, 108, 164, 187, 196

Australia

Melbourne

Univ. (University of Melbourne | http://www.unimelb.edu.au/), 24, 131

Perth

UWA (University of Western Australia | http://www.uwa.edu.au/), 30

Sydney

Univ. (University of Sydney | http://sydney.edu.au/), 24, 30, 108, 187

Austria

Innsbruck

Univ. (University of Innsbruck | http://www.uibk.ac.at/), 18, 131

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/), 131

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

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

Azerbaijan

Baku

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

BSU (Baku State University | http://bsu.edu.az/), 131

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://gia.az/), 131

IP ANAS (Institute of Physics of the Azerbaijan National Academy of Sciences | http://www.physics.mehdiyev.me/), 12, 42, 84, 140, 179, 187, 196

IRP ANAS (Institute of Radiation Problems of the Azerbaijan National Academy of Sciences | http://irp.science.az/), 102, 124, 131, 146

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

Belarus

Gomel

GSTU (Pavel Sukhoi State Technical University of Gomel | http://www.gstu.by/), 12, 33, 42, 74, 179

GSU (Francisk Skorina Gomel State University | http://new.gsu.by/), 12, 42, 64, 74, 84, 159, 196

MPRI NASB (V.A.Belyi Metal Polymer Research Institute of the National Academy of Sciences of Belarus | http://mpri.org.by/), 159

Minsk

BSTU (Belarusian State Technological University | http://www.belstu.by/), 24, 140, 149, 155, 173, 179, 187, 196

Belgium

Brazil

France

Kazakhstan

Russia

Arkhangelsk
- NArFU (Northern (Arctic) Federal University named after M.B.Lomonosov | http://narfu.ru/), 173, 197
- NSMU (Northern State Medical University | http://www.nsmu.ru/), 197

Astrakhan
- ASU (Astrakhan State University | http://asu.edu.ru/), 165

Belgorod
- BelSU (Belgorod National Research State University | http://www.bsu.edu.ru/), 14, 25, 86, 143, 197

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/), 133
- 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/), 168

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/), 160
- ISMAN RAS (Federal State Budgetary Institution of Science "Institute of Structural Macrokinetics and Materials Science of the Russian Academy of Sciences" | http://www.ism.ac.ru/), 99
- ISSP RAS (Federal State Budgetary Institution of Science "Institute of Solid State Physics of the Russian Academy of Sciences" | http://issp.ac.ru/), 74, 143, 160
- LITP RAS (Federal State Budgetary Institution of Science "L.D.Landau Institute for Theoretical Physics of the Russian Academy of Sciences" | http://www.itp.ac.ru/), 14, 31, 34, 87, 180
- SCC IPCP RAS (Federal State Budgetary Institution of Science "Supercomputer Centre of the Institute of Problems of Chemical Physics of the Russian Academy of Sciences" | http://www.icp.ac.ru/), 180

Dimitrovgrad
- SSC RIAR (Joint Stock Company "State Scientific Centre Research Institute of Atomic Reactors" Rosatom State Nuclear Energy Corporation | http://www.niiar.ru/), 120

Dolgoprudny
- MIPT (Moscow Institute of Physics and Technology (State University) | http://mipt.ru/), 66, 86, 143, 197

Dubna
- BSINP MSU (Branch of the Skobeltsyn Institute of Nuclear Physics of the Lomonosov Moscow State University | http://www.msu.dubna.ru/), 109, 197
- Diamant (Diamant LLC | http://diamant-sk.ru/), 133
- Dubna State Univ. (Dubna State University | http://www.uni-dubna.ru/), 125, 133, 143, 150, 174, 180, 189, 197
- EI (Engineering Incubator | http://in-cub.ru/node/2), 143
- IAS "Omega" (Institute for Advanced Studies "Omega" | http://dubna-oez.ru/), 109
- Lition (Lition LLC | http://www.lition.ru/), 143
- PELCOM ("Pelcom Dubna Mashinostroitelny Zavod" | http://pelcom.ru/), 86
- Progresstech (Dubna, "Progresstech" | http://progresstech.ru/), 86
- RDH-9 (Radiological Department of Hospital № 9 | http://msch9fmba.ru/radiologicheskoe-otdelenie-2/), 170
- SCC "Dubna" ("Dubna" Satellite Communication Centre, Branch of the Federal State Unitary Enterprise "Russian Satellite Communication Company" | http://www.rscc.ru/), 180
- SEZ "Dubna" (Special Economic Zone of Technical-Innovative type "Dubna" | http://oezdubna.ru/), 180
- Trackpore Technology (Closed Joint Stock Company "Trackpore Technology " Membrne Technologies and the Future Branch of the Dubna | http://www.trackpore.ru/), 160

Fryazino
- ISTOK (Joint Stock Company "Research and Production Corporation "ISTOK" named after Shokin" | http://www.istokmw.ru/), 87

Gatchina
- NRC KI PNPI (Federal State Budgetary Institution "B.P.Konstantinov Petersburg Nuclear Physics Institute" of the National Research Centre "Kurchatov Institute" | http://www.pnpi.spb.ru/), 14, 20, 25, 39, 45, 66, 86, 93, 105, 115, 120, 125, 133, 143, 150, 155, 168, 180, 189

Spain

Barcelona
- IEEC-CSIC (Institute of Space Science of the Higher Research Council | http://www.ice.csic.es/), 31
- IFAE (Institute for High Energy Physics | http://www.ifae.es/), 42

Bilbao
- UPV/EHU (University of the Basque Country | http://www.ehu.eus/), 31

Huelva
- UHU (University of Huelva | http://www.uhu.es/), 120

Madrid
- CENIM-CSIC (National Centre for Metallurgical Research of the Higher Research Council | http://www.cenim.csic.es/), 144
- CIEMAT (Centre for Energy, Environment and Technological Research | http://www.ciemat.es/), 66
- ETSIAE (Higher Technical School of Aeronautical and Space Engineering of hte polytechnic University of Madrid | http://www.etsiae.upm.es/), 31
- ICMM-CSIC (Materials Science Institute of Madrid of the Higher Research Council | http://www.icmm.csic.es/), 26
- UAM (Autonoma University of Madrid | http://www.uam.es/), 34, 66

Oviedo
- UO (University of Oviedo | http://www.uniovi.es/), 66

Palma
- UIB (University of the Balearic Island | http://www.uib.cat/), 20

Santander
- IFCA (Institute of Physics of Cantabria of the University of Cantabria | http://ifca.unican.cs/), 66

Santiago de Compostela
- USC (University of Santiago de Compostela | http://www.usc.es/), 14, 31

Valencia
- IFIC (Institute for Particle Physics of the University of Valencia | http://ific.uv.es/), 31
- UPV (Polytechnic University of Valencia | http://webific.ific.uv.es/), 146
- UV (University of Valencia | http://www.uv.es/), 14, 161

Sweden

Göteborg
- Chalmers (Chalmers University of Technology | http://www.chalmers.se/), 20, 120

Lund
- ESS ERIC (Europen Spallation Source ERIC Lund University | https://europeanspallationsource.se/), 150, 155
- LU (Lund University | http://www.lu.se/), 14, 20, 39, 105, 120, 180

Stockholm
- SU (Stockholm University | http://www.su.se/), 87

Uppsala
- TSL (Svedberg Laboratory of the Uppsala University | http://tsl.uu.se/), 94

Switzerland

Basel
- Uni Basel (University of Basel | http://www.unibas.ch/), 66, 174

Bern
- Uni Bern (University of Bern | http://www.unibe.ch/), 14, 20

Geneva
- UniGe (University of Geneva | http://www.unige.ch/), 99

Lausanne
- EPFL (Ecole Polytechnique Fédérale de Lausanne | http://www.epfl.ch/), 105

Villigen
- PSI (Paul Scherrer Institute | http://www.psi.ch/), 26, 45, 66, 94, 120, 133, 144, 150

Zurich
- ETH (Swiss federal Institute of Technology Zurich | http://www.ethz.ch/), 26, 61, 66, 144, 189
- UZH (University of Zurich | http://www.uzh.ch/), 66

Taiwan

Hsinchu
- NSRRC (National Synchrotron Radiation Research Center | http://www.nsrrc.org.tw/), 144

Taipei
- AS (Academia Sinica | http://www.sinica.edu.tw/), 71
- ASGC‘A (Academia Sinica Grid Computing Certification Authority | http://ca.grid.sinica.edu.tw/), 180
- IP AS (Institute of Physics of the Academia Sinica | http://www.phys.sinica.edu.tw/), 20, 26
- NTU (National Taiwan University | http://www.ntu.edu.tw/), 20, 66

Ukraine