**In total the completed form should not exceed 20 pages (together with tables).**

**Annex 3.**

***Form of opening (renewal) for Project /***

***Sub-project of LRIP***

**APPROVED**

**JINR DIRECTOR**

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**PROJECT PROPOSAL FORM**

Opening/renewal of a research project/subproject of the large research infrastructure project within the Topical plan of JINR

**1. General information on the research project of the theme/subproject of the large research infrastructure project (hereinafter LRIP subproject)**

* 1. **Theme code / LRIP** (for extended projects) - *the theme code includes the opening date, the closing date is not given, as it is determined by the completion dates of the projects in the topic.*

**1.2 Project/LRIP subproject code** (for extended projects)

**1.3 Laboratory** Bogoliubov Laboratory of Theoretical Physics

**1.4 Scientific field** Theoretical Physics

**1.5 Title of the project/LRIP subproject** Integrable systems and symmetries

**1.6 Project/LRIP subproject leader(s)** Isaev A.P., Krivonos S.O., Tyurin N.A.

**1.7 Project/LRIP subproject deputy leader(s) (scientific supervisor(s))**

**2 Scientific case and project organization**

**2.1 Annotation**

The project is devoted to important aspects of the modern mathematical physics, related to the studies of integrable systems and their symmetries.

The first important problem comes from high energy physics, considered in the context of holographic duality. This part of the project is devoted to the studies of the properties of important integrable systems, arise in different holographic systems. The principal meaning here

comes with the holographic relation, making it possible to realize a non trivial duality between gravitational and gauge theories in different dimensions and with different connection levels. The last one sufficiently generalizes the possible studies of complicated models with interesting effects.

Approaches, using for the analysis of the systems, mainly based on well developed methods of group theory, algebra, differential geometry and integrable systems. The presence of integrable structures in certain models leads to non trivial checking of the holographical idea and opens new horizons in high energy physics. At the same time mostly presented equations, describing the properties of the models, are Fuchs equations which is highly developed and can be applied in the studies of the systems. On the other hand, different algebraic and differential transformations, such as the Mobius transformations, Schwarzian derivation, Schwarz - Cristoffel transformations and many others, encoded non trivial information on

the nature of the models, present a strong tool for the studies of the integrable models. Presence of these structures in the complicated systems makes their analytical studies and often leads to discoveries of new interesting relations behind different objects.

The second important problem of our project is closely related to the first one since it deals with field theories with extended supersymmetries, important objects for investigations in mathematical physics, which help in the studies of general properties of quantum field theories and many aspects of the string theories. In particular one of the applications of the supersymmetrical field theories is effective description of extended objects, which appear in the string theory and M - theory (branes). So D - brane can be effectively described in the lowest approximation by the supersymmetrical Maxwell theory of certain dimension, and taking into account non linear effects - by the Born - Infeld theory. Couples of coinciding branes have different degrees of freedom and can be described by SU(n) supersymmetrical Yang - Mills theory. As it was shown by Ed. Witten, couples of M5- branes can be described in the lowest approximation by a six dimensional field theory with N=(2,0) supersymmetry. This theory additionally is superconformal and it realizes maximal possible superconformal symmetry. The formulation of this theory must include non abelean tensor multiplet, which is a generalization of the standard one, which contains 5 scalars, Majorana fermion and self dual 2 - form, and following a no - go theorem this must contains as well certain additional fields. Some approaches here lead to theories with non dynamical tensor fields, some others - with dynamical ones and additional Yang - Mills fields.

On the other side of holographic duality one has an important problem of description of unitary irreducible representations of Poincare groups in higher dimensions and symmetry groups of Anti de Sitter spaces AdS. According to Wigner each unitary irreducible representation of four dimensional Poincare group corresponds an elementary particle (field). This conception can be generalized to the case of arbitrary dimensions and to the case of other groups (including supergroups). Therefore for studies of other field models at the first stage one asks about classification and explicit construction of unitary irreducible representation of the symmetry group of the desired theory.

Furthermore, the next important problem of our project arises under the well known effect in holography, namely since the volume of Anti de Sitter space the computed by holographical methods values are subject to divergency therefore it requires certain renormalization procedure like the renormalization method in quantum field theory. Holographical renormalization includes the notion of the flow of holographical renormgroup, which correctly describes the deformation of the space - time AdS. Renorngroup flow in this case is geometrically presented and corresponds to a gravitational solution with special asymptotical properties. These solutions are invariant under the Poincare group action and they are called solution of the domen wall type since they interpolate between two domains, both of which corresponds to certain fixed point of the dual quantum field theory. The choice of the boundary conditions for holographical flow corresponds to specified renormalization scheme and deformation description. For example, the boundary Dirichlet conditions make it possible to interpret

the corresponding holographical RH flow as a deformation of the dual CFT using two possible ways: either by relevant one trace operator or vacuum expected value (VEV) of scalar operator (one point). At the same time one can extend the holography vocabulary using the Neumann conditions or mixed boundary conditions, so the holographical RH flow shall correspond to a deformation of the dual CFT by many traces operators. Particular case of the last deformation is deformation by the determinant of the energy momentum tensor or T\bar{T}- deformation, which admits a very nice property: the corresponding deformed theory is integrable, which means that the energy spectrum of the theory is known at each deformation stage. This correspondence between the studies of RH flow and the integrability property of the deformed dual theory leads to a number of very interesting and important problems, and our project is devoted to their studies.

The modern string theory presents two types of theories related to each other by certain duality called mirror symmetry. On the level of D - branes these types are distinguished by the boundary types for open strings: while in the type B theories the boundary conditions are given by certain holomorphic data, coming from the complex geometry, in the type A theory the boundary conditions are given by lagrangian submanifolds so they are generated by symplectic geometry. Thus Yu.I. Manin presented mirror symmetry on the most generic level as a miracle duality between complex geometry and symplectic geometry. However these geometries are very different of one takes into account the degree of freedom of possible deformations: for the complex case the deformations are always finite while in the symplectic case one has continuum infinite deformation spaces. Therefore for a specialization of the Manin slogan one needs to find in symplectic geometry some new constructions such that one shall get finite dimensional objects. Recently one knew only one construction of the desired type: Special Lagrangian geometry which works for the case when the target space is Calabi - Yau manifold. In terms of this geometry one proposed a solution of the S - duality problem in the construction of Strominger - Yau - Zaslow (as well in the papers of C. Vafa, E. Witten and other). As a much more applicable alternative one proposed a new programme which was called Special Bohr - Sommerfeld geometry. The last one can be applied for the case of any algebraic variety as the target space, not Calabi - Yau only; and in the last case this theory leads to a moduli space which is transversal to the moduli space of special lagrangian cycles, and this gives us some additional numerical invariants. The investigations in this way appeared to be quite effective and interesting for certain old problems as well, related to geometric quantization and quasi classical approximations.

**2.2 Scientific case** (aim, relevance and scientific novelty, methods and approaches, techniques, expected results, risks)

Thematically, the project belongs to the field of high energy physics, considered in the context of holographic duality. This is a dynamically developing field in which unsolved problems of a fundamental nature are considered, causing the ongoing interest of physicists and mathematicians. It should also be noted that the relevance and rapid development of the chosen topic implies a certain possibility of modifying the specifics of the initially set tasks in the process of their implementation within the project, but not their nature.

This part of the project is aimed at studying the properties of important integrable structures found in various holographic systems. Of fundamental importance here is the principle of holographic correspondence, which makes it possible to realize a non-trivial dualism between gravitational and gauge theories in different dimensions and with different communication modes. The latter significantly expands the possibilities of studying complex models with interesting effects.

The principle of holography [1] allows for a correspondence between the gravitational theory in a space with a certain number of dimensions and the quantum field theory living on the boundary of this space. The advantage of holographic duality is its ability to connect different modes of interaction in two theories. In this sense, calculations in the weak-coupling mode of one of the theories can be transferred to the strong-coupling mode of another theory. The study of the properties of this duality turns out to be an extremely non-trivial task, requiring the use of a number of different methods and techniques. In this regard, one of the most effective ways to study holographic systems is integrability. Powerful methods developed in the framework of integrable systems can be directly applied to the study of holographic dual theories. The presence of integrable structures in these models leads to nontrivial tests of the holographic principle [2] and opens up new interesting horizons in high-energy [3] and condensed matter physics [4] .

One of the innovative nonperturbative approaches used to analyze the properties of integrable systems is the method of isomonodromic deformations. In the framework of this approach, we seek to translate the initially arising boundary value problem of linear differential equations of motion, which describes the models of interest, into the original problem for nonlinear equations of the Painlevé type. At first glance, the price to be paid is the replacement of simpler linear equations with more complex non-linear ones, but thanks to progress in understanding the properties of the Painlevé equations, the latter can give very non-trivial results. The search for a connection between linear differential equations and integrable nonlinear equations is not a new problem and goes back to the classical works of Fuchs, Garnier and Schlesinger [5]. In the 1980s, this research was enriched by the pioneering work of Jimbo, Miwa, and Ueno [6], who brought the topic into the modern context of integrable systems. Moreover, these authors find a close connection between the nonlinear Painlevé equations and isomonodromic transformations of the linear Fuchs equations. Another breakthrough in the theory of isomonodromic deformations of linear systems was made by Kitaev, Itz, and Novokshonov [7], who studied the asymptotic properties of solutions to the Painlevé equations. These and other similar developments in the theory of linear and nonlinear ordinary differential equations quickly find practical application in various fields of physics, such as: conformal field theories [8], the theory of random matrix models [9], supersymmetric theories [10], integrable systems [11] , black holes [12] and others.

The approaches used to analyze such systems are mainly based on the well-established methods of group theory, algebra, differential geometry, and integrable systems. The presence of integrable structures in some models leads to a nontrivial verification of the holographic principle and opens up new horizons in high energy physics. In this case, the most common equations describing the properties of the models under consideration are the Fuchs equations, the theory of which is well developed and can be directly applied to the analysis of the systems under study. On the other hand, various algebraic and differential transformations, such as the Möbius transformation, the Schwartz derivative (Schwarzian), the Schwartz-Christoffel transformation, and others that encode non-trivial information about the nature of these models, are a powerful tool for studying integrable models. The appearance of these structures in complex systems facilitates their analytical processing and often leads to the discovery of new interesting relationships between seemingly different objects.

Furthermore, in the context of holography, the dual quantum field theory can be embedded in a finite temperature naturally induced by the corresponding black hole in the bulk. Atypical example is the Kerr-AdS/QGP correspondence [13], where the properties of strongly correlated quark gluon plasma can be studied within the supergravity approximation. It will be curious to investigate the thermodynamic stability of such systems. The latter has the potential to open a window into nonperturbative quantum effects beyond the supergravity approximation. Another avenue of investigation is to consider the relation between thermodynamic and dynamic stability. Study of fluctuation theory and its relation to thermodynamic information geometry could also be explored. Finally, one could also study the relation of thermodynamic stability and holographic complexity of black holes.

In the context of the holographic correspondence hypothesis and its testing, we will focus on research in the following general areas: first, integrable structures in conformally symmetric holographic models and those with a finite temperature where the conformal symmetry is broken; second, construction of exactly solvable holographic models and obtaining exact string classes solutions, semiclassical quantization and dispersion relations; third, application of information spaces and methods of information geometry in holographic duality, including those with finite temperature; and finally geometric and information flows in dual holographic theories and their applications.

In the near future, as part of the implementation of this project, our attention will be directed to solving the following three specific tasks. On the one hand, we will focus on the derivation of the coupled Fuchs equations for holographic models in various low- and high-dimensional spaces with known dual gauge theories. The focus of our study will be on the properties and integrability of these models in the presence of different sample fields. On the other hand, we will look for a direct connection between the direct boundary value problem associated with the initially arising linear Fuchs equations and the corresponding original Cauchy problem. This is achieved by the method of isomonodromic deformations of the solutions of the original equations of motion of the nonlinear Painlevé equations. Our goal is to take advantage of the developed analytical and numerical procedures associated with the theory of these equations and their solutions. Finally, we will focus our efforts on studying the considered models using differential structures such as the Schwartz derivative and the Schwartz-Christoffel transform, thereby contributing to a deeper understanding of these objects and their meaning in the context of holographic matching. The current research project proposes specific tasks that are part of a more general program in the field of modern theoretical physics and are of great interest in this area.

In [14,15], holographic RG flows of a truncated 5-dimensional supergravity model were constructed using the reduction of the gravitational action to an integrable mechanical system (Toda chain). In [16, 17], a generalization to the final temperature was obtained and studied, which contains the Hawking-Page phase transition.

In [18], holographic RG flows were studied for a 3D N=2 supergravity model with a scalar field and a potential depending on some real parameter. The RG flow equations are reduced to an autonomous first-order dynamical system. Equilibrium points of this system are found, which correspond to fixed points of dual field theories. Stability analysis and bifurcation analysis are performed. For the equilibrium points, asymptotic solutions for the metric and the scalar field are constructed, three of which correspond to the AdS metric, and the remaining three to the metrics of space-times with hyperscaling. Using the found asymptotic solutions and stability analysis, holographic RG flows are constructed. An analysis is carried out for the correspondence with the deformations of dual field theories, taking into account the Dirichlet boundary conditions. It is shown that the RG flows corresponding to CFT deformations by relevant operators are nonsingular, in contrast to the flows corresponding to deformations by nonzero VEVs of scalar operators.

In this framework we will work on the following problems. The description of holographic RG flows at finite temperature (corresponding to gravitational solutions like black holes) in 3-dimensional N=2 supergravity will be performed using the ADM decomposition. This will make it possible to obtain a generalization of the renormalization group equations at finite temperature in the framework of holographic duality. Holographic RG flows in 3-dimensional N=2 supergravity at finite temperature will be investigated using the theory of dynamical systems, which will make it possible to describe phase transitions using bifurcation analysis [18]. A global phase portrait of a dynamical system describing a holographic thermal RG flow will be constructed. Within the framework of holographic duality for a 3D N=2 supergravity model, multitrace deformations will be investigated using the mixed boundary and Neumann conditions. A holographic description of the T\bar{T}-deformation arising in 3-dimensional supergravity will be obtained and its connection with black hole-type solutions in this theory will be investigated.

Field theories with extended supersymmetry are an important subject of research in mathematical physics, which help to study general properties of quantum field theories and many aspects of string theories. In particular, one of applications of supersymmetric field theories is effective description of extended objects which appear in string an M-theories (branes). Single D-brane can be effectively described by supersymmetric Maxwell theory of appropriate dimension, and, if nonlinearities are taken into account, the Born-Infeld theory. Stacks of branes possess different number of degrees of freedom and are described by supersymmetric su(n) Yang-Mills theory [19]. E. Witten in [20] showed that stacks of M5-branes can be desribed in the lowest approximation by six dimensional field theory with N=(2,0) supersymmetry. This theory is also superconformal and realizes maximally possible superconformal symmetry [21]

Formulation of this theory have to include nonabelian tensor multiplet, which is generalization of the standard one, consisting of 5 scalars, Majorana fermion and self-dual 2-form, and due to no-go theorem [22] has to include additional fields. Some approaches to this problem [23] lead to theories with non-dynamical tensor fields, some - to dynamical ones with presence of additional Yang-Mills fields [24].

Most research done on this theory uses its component formulation. Therefore, it seems desirable, to study its quantum properties in particular, to construct the the superfield formulation of this theory with off-shell N=(1,0) supersymmetry, starting from the already constructed action of

abelian tensor multiplet [25], and also to find relations between different approaches to the (2,0) superconformal theory. Also it seems interesting to use the mechanism of generation of self-duality equations [25] in the context of N=(1,0), d=6 supergravity.

The investigations being carried out are related to theories containing fields with higher spins. Such theories are associated with the expansion of gravitational models that can be leading in the future to the possibility of describing quantum gravity [26]. General problem is related to unitary irreducible representations of multidimensional Poincare groups and symmetry groups of AdS (anti-de Sitter) spaces. According to Wigner, each unitary irreducible representation of the four-dimensional Poincare group is associated with an elementary particle (field). This conception is generalized to the case of arbitrary dimension and to the case of groups other than the Poincaré group (including supergroups). Therefore, when studying various field models, the first question is the classification and explicit construction of unitary irreducible representations of the symmetry group of the desired theory.

The project will be devoted to some explicit constructions of representations of the Poincaré groups and symmetry groups of AdS spaces. The general classification of unitary irreducible representations of ISO(1,D-1) (Poincare groups in D-dimensional spacetime) is well known (see the modern description in the lectures [27]), but constructing the corresponding fields explicitly involves various difficulties. First, starting from the dimension D>4, there appear unitary irreducible representations of the so-called mixed type of symmetry (parametrized by Young diagrams), whose covariant form (in terms of tensor fields) is known only for some classes of Young diagrams. To solve this problem, there are several different approaches, for example, in the work [28] this problem was reduced to the Brauer algebra formalism. Secondly, using the Wigner scheme (constructing unitary irreducible representations of the Poincaré groups as induced from the representations of the test momentum stability subgroup), we obtain a non-covariant construction – the Wigner wave function. The Wigner generalized operator method can be applied to construct the corresponding local relativistic field from the Wigner wave function. In a dimension equal to four, this method was applied to massive representations in the work [29], for representations with continuous (infinite) spin in [30] and for massless representations in work [31]. This method sometimes makes it possible to automatically find the equations of motion for relativistic fields. It is very attractive from the point of view of constructing the corresponding Lagrangian theory.

The symmetry group of a D-dimensional anti-de Sitter space is the SO(D-1,2) group. The classification of its unitary irreducible representations is known (see for e.g.[32])

and in general they are characterized by two parameters (E,Y) , where E is a real number and Y is the Young diagram associated with the representation of the SO(D-1) group. When studying these representations, the conception of the so-called unitarity bound arises. This is a restriction on the parameter E, which, for the representation to be unitary, must be greater than or equal to some number associated with the diagram Y. It is also known that for a given representation (E,Y) this number coincides with the conformal dimension of the conserved current. It is some representation (which corresponds to a Y-type diagram) of the conformal group of the (D-1)-dimensional Minkowski space. Note that when E is equal to the corresponding conformal dimension of the conserved current, representations arise that are associated with gauge fields in AdS. Here, the explicit constructions of fields in AdS in various dimensions are also of interest, especially in connection with studies within the framework of the AdS/CFT correspondence or its variant, the so-called higher-spin holography (see for e.g. [33]).

Using the Brauer algebra formalism, it is planned to find explicit constructions of relativistic fields of mixed symmetry type corresponding to the most general Young diagrams. Also, within the project it is planned to study the connection between covariant SO(D-1,2)-tensors (found as idempotents of the Brauer algebra, taken in the corresponding representation) with unitary irreducible representations of the symmetry group of AdS spaces. Further with the help of the generalized Wigner operator, representations of Poincaré groups in the dimension D>4 will be studied. For example, for the dimension D=6 in the work [34] a detailed classification of massless representations with finite helicity and representations with continuous (infinite) spin was described. The results of this work can be used to find the explicit construction of the corresponding relativistic fields by the method of the generalized Wigner operator.

The conception of the unitarity bound described in item 2 naturally arises in gravitational models in the study of the AdS/CFT correspondence. Namely, the field mass in the gravitational theory with a conformal boundary is associated with the scale (conformal) dimension of some field of the conformal theory “living” on the boundary. This is expressed by a relation that is quadratic in the conformal dimension, which leads to a restriction (similar to the condition of the unitarity bound) on the square of the field mass. We will study holographic renormalization group flows [18] of supergravity theories with a black hole, corresponding to CFT with nonzero temperature. In this case, the conformal dimension of fields in CFT will be related to some parameter of the potential of the gravitational theory. This parameter is determined by the radius of the homogeneous space of the corresponding sigma model.

Our project as well supposes that together with a group of scientists from the Accelerator Department of the Laboratory of High Energy Physics will solve the problem of optimizing the calculations of the simulation of the beam motion (especially when studying the stability of the beam orbit) in the NICA accelerator complex. Namely, it is proposed to reduce some of the numerical calculations to analytical ones, using the apparatus of the theory of Lie groups and algebras, in the framework of the Lie method (see for e.g. [35]).

Using characteristic identities we plan to construct some universal formulas for projectors to invariant subspaces and find the corresponding eigenvalues of the split Casimir operator in the tensor product of four or more adjoint representations of simple Lie algebras and Lie superalgebras. We plan to find a universal description of the defined characteristic identities,

invariant projectors and (quantum) dimensions of the corresponding invariant subspaces in the Vogel parameter terms. We plan to exploit the split Casimir operators and their characteristic identities in our search of color factors of the Feynman diagrams in non abelian quantum gauge field theories.

Nowadays one knows universal formulas (common for all simple Lie algebras) for dimensions , projectors and high Casimir operators for all irreducible representations of simple Lie algebras and certain Lie superalgebras from classical series, which belong to the representation (ad x ad) [36], [37], [38], [39], [40]. As well one knows explicit universal formulas of the dimensions for some irreducible representations contained by representation (ad x ad x ad) for all simple Lie algebras. Very little is known about universal description of representations in (ad x ad x ad x ad). One should mention here results from [41], where one has derived the universal formulas for some subrepresentations in (ad x ad x ad x ad) for the exceptional Lie algebras only. Finally one should mention possible applications of the universal desription of simple Lie algebras (and its quantum deformations) in the studies of quantum Chern - Simons theories [42], in particular for certain universal description of "adjoint" polynomials of knots [43].

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**2.3 Estimated completion date**

**2.4 Participating JINR laboratories**

**2.4.1MICC resource requirements**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Computing resources** | **Distribution by year** | | | | |
| 1st year | 2nd year | 3rdyear | 4th year | 5th year |
| Data storage (TB)  - EOS  - Tapes |  |  |  |  |  |
| Tier 1 (CPU core hours) |  |  |  |  |  |
| Tier 2 (CPU core hours) |  |  |  |  |  |
| SC Govorun (CPU core hours)  - CPU  - GPU |  |  |  |  |  |
| Clouds (CPU cores) |  |  |  |  |  |

**2.5. Participating countries, scientific and educational organizations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Organization** | **Country** | **City** | **Participants** | **Type**  **of agreement** |
| University | Australia | Sydney | MolevA. | Collaborations |
| Yerevan Physics Institute | Armenia | Yerevan | Hakobian Т.  МанвелянР.  Mkrttchyan R.  Demirchian H.  Khastyan E.  Avetisyan M. | Visits exchange  Collaborations |
| INRNEBAS | Bulgaria | Sofia | Dobrev V.  Iliev B.  Todorov I.T. | Visits exchange |
| Sofia Univ.  St.Kliment Ohridski | Bulgaria | Sofia | Rashkov R.  Ivanov C. | Visits exchange  Collaborations |
| University | Germany | Hanover | Lechtenfeld O.  Dragon N. | Collaborations |
| IPO | Germany | Oldenburg | Grunau S.  Kleihaus B.  Kunz J.  Azad B. | Collaborations |
| University | Italy | Padova | Basseto A.  Sorokin D. | Agreement |
| University | China | Shanghai | Korobkov M. | Visits exchange |
| University | Poland | Wroclaw | Popowicz Z.  Borowiec A.  Lukierski J.  Frydryszak A. | Visits exchange Collaborations |
| University | Poland | Bialystok | Odzievich A. | Visits exchange |
| ITEP | Russian Federation | Moscow | Morozov A.  Mironov A.  Rosly A.  Olshanetsky M. | Visits exchange |
| MSU | Russian Federation | Moscow | Galtsov D.  Sveshnikov K.  Talalaev D.  Shafarevich А.  Stepanyantz К. | Visits exchange Collaborations |
| MIRAS | Russian Federation | Moscow | Arefeva I.  Orlov D.  Slavnov N.  Volovich I.  Katanaev M. | Visits exchange |
| Ishinsky Institute for Problems in Mechanics | Russian Federation | Moscow | Dobrohotov S. | Visits exchange |
| MIPT | Р Russian Federation Ф | Долгопрудный | Musaev E.  Bondal А. | Collaborations |
| Higher School of Economics | Russian Federation | Moscow | Pushkar P. | Visits exchange |
| Skoltech | Russian Federation | Skolkovo | Kazaryan М. | Visits exchange |
| St. Petersburg Department of Steklov Mathematical Institute | Russian Federation | St. Petersburg | Derkachev S. | Collaborations |
| Voronezh University | Russian Federation | Voronezh | Minakov А. | Visitsexchange |
| KPFU | Russian Federation | Kazan | Sushkov S.  Popov А. | Collaborations |
| Sobolev Mathematical Institute | Russian Federation | Novosibirsk | Mironov А. | Visits exchange |
| Landau Institute for Theoretical Physics | Russian Federation | Chernogolovka | Belavin А.  Sokolov V.  Starobinsky А. | Visits exchange |
| Technical University | Czech Republic | Prague | Burdik Ch. | Visits exchange Collaborations |
| Obsrvatoire de Paris | France | Paris | Gourgoulhon E. | Collaborations |
| ENS | France | Paris | Policastro G. | Collaborations |

**2.6. Key partners** *(those collaborators whose financial, infrastructural participation is substantial for the implementation of the research program. An example is JINR's participation in the LHC experiments at CERN).*

**3. Manpower**

**3.1. Manpower needs in the first year of implementation**

|  |  |  |  |
| --- | --- | --- | --- |
| **№№**  **n/a** | **Category of personnel** | **JINR staff,**  **amount of FTE** | **JINR Associated**  **Personnel,**  **amount of FTE** |
| 1. | research scientists | 7 |  |
| 2. | engineers |  |  |
| 3. | specialists | ~~2~~ |  |
| 4. | office workers |  |  |
| 5. | technicians |  |  |
|  | **Total:** |  |  |

**3.2. Available manpower**

**3.2.1. JINR staff**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Category of personnel** | **Full name** | **Division** | **Position** | **Amount**  **of FTE** |
| 1. | research scientists | Tyurin Nikolaj Andreevich |  | Head of Sector | 1 |
| Isaev Aleksej Petrovich |  | Principal Researcher | 1 |
| Vavrzhicki Yaroslav Vojchekh |  | Senior Researcher | 1 |
| Golubcova Anastasiya Andreevna |  | Senior Researcher | 1 |
| Dimov Hristo |  | Senior Researcher | 1 |
| Kozyrev Nikolaj Yur'evich |  | Senior Researcher | 1 |
| Podoinitsyn Mihail Aleksandrovich |  | Researcher | 1 |
|  |  |  |  |  |  |
| 2. | engineers |  |  |  |  |
|  |  |  |  |  |  |
| 3. | specialists | Provorov Aleksandr Alekseevich |  | trainee researcher | 1 |
| Arhipova Kseniya Yur'evna |  | Senior Assistant | 0,5 |
| Gejtota Olesya Vyacheslavovna |  | Senior Assistant | 0,5 |
| 4. | technicians |  |  |  |  |
|  | **Total:** |  |  |  | **9** |

**3.2.2. JINR associated personnel**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Category of personnel** | **Partner organization** | **Amount of FTE** |
| 1. | research scientists |  |  |
| 2. | engineers |  |  |
| 3. | specialists |  |  |
| 4. | technicians |  |  |
|  | **Total:** |  |  |

**4. Financing**

**The project will be financially supported in the framework of Thema “Modern Mathemtaical physics: integrability, gravity and supersymmetry”**

**Project (****LRIP subproject) Leader** \_\_\_\_\_\_\_\_\_\_/\_\_\_\_\_\_\_\_\_\_\_/

Date of submission of the project (LRIP subproject) to the Chief Scientific Secretary: \_\_\_\_\_\_\_\_\_

Date of decision of the laboratory's STC: \_\_\_\_\_\_\_\_\_ document number: \_\_\_\_\_\_\_\_\_

Year of the project (LRIP subproject) start: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(for extended projects) – Project start year: \_\_\_\_\_\_\_

**Proposed schedule and resource request for the Project / LRIP subproject**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Expenditures, resources,**  **funding sources** | | | **Cost (thousands**  **of US dollars)/**  **Resource requirements** | **Cost/Resources,**  **distribution by years** | | | | |
| 1st year | 2nd year | 3rdyear | 4th year | 5th year |
|  | | International cooperation |  |  |  |  |  |  |
| Materials |  |  |  |  |  |  |
| Equipment, Third-party company services |  |  |  |  |  |  |
| Commissioning |  |  |  |  |  |  |
| R&D contracts with other research organizations |  |  |  |  |  |  |
| Software purchasing |  |  |  |  |  |  |
| Design/construction |  |  |  |  |  |  |
| Service costs (*planned in case of direct project affiliation)* |  |  |  |  |  |  |
| **Resources required** | **Standard hours** | Resources |  |  |  |  |  |  |
| * the amount of FTE, |  |  |  |  |  |  |
| * accelerator/installation, |  |  |  |  |  |  |
| * reactor,… |  |  |  |  |  |  |
| **Sources of funding** | **JINR Budget** | JINR budget *(budget items)* |  |  |  |  |  |  |
| **Extra fudning (supplementary estimates)** | Contributions by  partners  Funds under contracts with customers  Other sources of funding |  |  |  |  |  |  |

Project (LRIP subproject) Leader\_\_\_\_\_\_\_\_\_/\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_/

Laboratory Economist \_\_\_\_\_\_\_\_\_/\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_/

**APPROVAL SHEET FOR PROJECT / LRIP SUBPROJECT**

TITLE OF THE PROJECT/LRIP SUBPROJECT

SHORT DESIGNATION OF THE PROJECT / SUBPROJECT OF THE LRIP

PROJECT/LRIP SUBPROJECT CODE

THEME / LRIP CODE

NAME OF THE PROJECT/ LRIP SUBPROJECT LEADER

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | |
| AGREED |  |  |  | |
| JINR VICE-DIRECTOR | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE |  |
| CHIEF SCIENTIFIC SECRETARY | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE |  |
| CHIEF ENGINEER | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE |  |
| LABORATORY DIRECTOR | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE |  |
| CHIEF LABORATORY ENGINEER | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE |  |
| LABORATORY SCIENTIFIC SECRETARY  THEME / LRIP LEADER | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_  DATE |  |
| PROJECT / LRIP SUBPROJECT LEADER | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE |  |
|  |  |  |  |  |
| APPROVED BY THE PAC | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE | |

**Annex 4.**

***Project (LRIP subproject) report form***

**PROJECT REPORT**

**1. General information on the project** **/ LRIP subproject**

**1.1. Scientific field**

**1.2. Title of the project / LRIP subproject**

**1.3. Project (LRIP subproject) code**

***Example (04-4-1140-1-2024/2027)***

**1.4. Theme / LRIP code**

***Example (theme 04-4-1140-2024,* MIP *04-4-1140-2024)***

**1.5. Actual duration of the project/ LRIP subproject**

**1.6. Project / LRIP subproject Leader(s)**

**2. Scientific report**

**2.1. Annotation**

**2.2. A detailed scientific report**

2.2.1. Description of the mode of operation and functioning of the main systems and equipment

(for the LRIP subproject).

2.2.2. A description of the conducted experiments (for experimental projects).

2.2.3. A description of the research undertaken and the results obtained.

2.2.4. A list of the main publications of the JINR authors, including associated personnel on the results of the project (list of bibliographical references).

2.2.5. A complete list of publications (electronic annex, for journal publications with journal impact factor).

2.2.6 List of talks given at international conferences and meetings (electronic annex).

2.2.7. Patent activity (if any)

**2.3. Status and stage (TDR, CDR, ongoing project) of the project (subproject) (including percentage of implementation of the declared milestones of the project (LRIP subproject)** *(if applicable)*

**2.4. Results of related activities**

2.4.1. Research and education activities. List of defended dissertations.

2.4.2. JINR grants (scholarships) received.

2.4.3. Awards and prizes.

2.4.4. Other results (expert investigation, organizational, outreach activities).

**3. International cooperation**

Actually participating countries, institutions and organizations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Organization** | **Country** | **City** | **Participants** | **Type**  **of agreement** |
|  |  |  |  |  |
|  |  |  |  |  |

**4. Analysis of planed vs actually used resources: manpower (including associated personnel), financial, IT, infrastructure**

**4.1 Manpower** (actual at the time of reporting)

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Personnel category** | **JINR staff,**  **amount of FTE** | **JINR associated personnel,**  **amount of FTE** |
| 1. | research scientists |  |  |
| 2. | engineers |  |  |
| 3. | specialists |  |  |
|  | **Total:** |  |  |

**4.2 The actual estimated cost of the project/ LRIP subproject**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Names of costs, resources, funding sources** | | | **Cost (thousands**  **of US dollars) / Resource request** | **Proposal from**  **the laboratory for allocation of funding and resources** | | | | |
| 1  year | 2  year | 3  year | 4  year | 5 year |
|  | | International cooperation |  |  |  |  |  |  |
| Materials |  |  |  |  |  |  |
| Equipment, Third-party company services |  |  |  |  |  |  |
| Commissioning |  |  |  |  |  |  |
| R&D contracts with other research organizations |  |  |  |  |  |  |
| Software purchasing |  |  |  |  |  |  |
| Design/construction |  |  |  |  |  |  |
| Service costs (*planned in case of direct project affiliation)* |  |  |  |  |  |  |
| **Resources required** | **Standard hours** | Resources |  |  |  |  |  |  |
| * the amount of FTE, |  |  |  |  |  |  |
| * accelerator/installation, |  |  |  |  |  |  |
| * reactor,… |  |  |  |  |  |  |
| **Sources of funding** | **JINR Budget** | JINR budget *(budget items)* |  |  |  |  |  |  |
| **Extra fudning (supplementary estimates)** | Contributions by  partners  Funds under contracts with customers  Other sources of funding |  |  |  |  |  |  |

**4.3 Other resources**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Computer resources consumed**  **MICC** | **Distribution by years** | | | | |
| **1st year** | **2nd year** | **3rdyear** | **4th year** | **5th year** |
| Data storage (TB)  - EOS  - Tapes |  |  |  |  |  |
| Tier 1 (CPU core hours) |  |  |  |  |  |
| Tier 2 (CPU core hours) |  |  |  |  |  |
| SC Govorun (CPU core hours)  - CPU  - GPU |  |  |  |  |  |
| Clouds (CPU cores) |  |  |  |  |  |

**5. Conclusion**

**6. Proposed reviewers**

**Theme / LRIP Leader**

**/\_\_\_\_\_\_\_\_\_\_\_\_\_\_/**  
**" " 202\_г.**

**Project leader (project code) / LRIP subproject**

**/\_\_\_\_ /**  
**" " 202\_г.**

**Laboratory Economist**

**/\_\_\_\_\_\_\_ /  
" " 202\_ г.**