**Annex 3.**

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

***Sub-project of LRIP***

**APPROVED**

**JINR DIRECTOR**

**/**

**" " 202 г.**

**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** BLTP

**1.4 Scientific field Theoretical Physics**

**1.5 Title of the project/LRIP subproject**

Phenomenology of strong interactions and precision physics

**1.6 Project/LRIP subproject leader(s)**

V.I. Korobov, M.A. Ivanov

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

**2 Scientific case and project organization**

**2.1 Annotation**

**Key words:**

Effective quantum field theories. Low energy QCD. Fundamental physical constants. Precision physics and the search for new interactions.

The project is expected to develop low-energy effective field theories: non-relativistic quantum electrodynamics (NRQED) and covariant quark model of hadrons (Covariant Confined Quark Model, CCQM).

The success of the Standard Model (SM) in describing a significant amount of experimental data is largely due to the development of so-called effective theories. Roughly speaking, a quantum effective theory is a quantum field theory that is not fundamental, its scope is limited to a certain range of energies, as a rule, such theories are not renormalizable in the usual sense. The effective Lagrangian consists of a chain of local operators, each of which is characterized by a corresponding coefficient (effective coupling/Wilson coefficient). The chain of operators is organized as series in ascending order of dimension. The wide separation of the energy scale from the mass of the W-boson to the masses of the B-meson or charmed particles has made it possible to successfully use effective theories and methods of the renormalization group to calculate experimentally observed quantities with amazing accuracy. It should be noted that the main theoretical uncertainty lies in the calculation of the matrix elements of the operators of effective theories. These calculations require going beyond perturbation theory and, as a consequence, the use of such approaches as lattice calculations, QCD sum rules, and various quark models. In this project, for this purpose, the covariant model of quarks is used, which has found wide application in the description of exclusive processes involving both mesons and baryons, and exotic states such as tetraquarks.

NRQED is effectively used to calculate the bound states of light atoms and molecules. Comparison with experiment makes it possible to improve the values of fundamental physical constants, such as the Rydberg constant, the proton-to-electron mass ratio, the proton charge radius, etc. With the help of precision spectroscopy, it is possible to measure the masses of negatively charged pions, kaons, antiprotons with high accuracy, to obtain restrictions on the possible manifestations of new interactions between hadrons, on the hypothetical "fifth force". Precise measurements of the transition frequencies of cold molecules in traps are of great importance for construction of optical clocks in the terahertz and radio ranges.

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

The Standard Model of particle physics, formulated about 50 years ago, forms the basis of our understanding of fundamental interactions. The SM as a quantum field theory describes how the basic constituents of matter (quarks and leptons) interact at the microscopic level through weak, strong and electromagnetic forces. Although all data from ground-based laboratory experiments are consistent with the SM predictions, perhaps, apart from some exceptions that will be commented on later, there is some indirect evidence obtained from cosmological observations that the model is not complete: this model cannot explain the baryon asymmetry of the Universe, dark matter and dark energy. All these phenomena could naturally find their explanation in the field of elementary particle physics or, in a more general sense, in QFT. There are also internal problems of the SM itself, such as the problem of the mass hierarchy, the absence of a path to quantum gravity. In addition, nonvanishing neutrino masses cannot be explained in terms of the classical version of the SM, which contains only left-handed neutrinos and only renormalizable interactions. To solve these problems, a large number of new theories beyond the Standard Model (BSM) have been created. These include supersymmetric models, models with compositeHiggs sectors, and/or composite quarks and leptons. These models have new particles and interactions, typically at energies above the Fermi scale. They were created to explain some facts that cannot be explained in the SM, such as the quantization of electric charge, the hierarchical structure of generations of quarks and leptons, the possible unification of interactions, etc. Unfortunately, many predictions of such models either do not agree with the data , or are not verifiable using existing or planned experimental devices.

Over the years, significant theoretical work has been carried out to improve the calculation technique and increase the accuracy of predictions in the SM. In addition to the development of new calculation methods, progress has been made possible by the development and application of effective field theory (EFT) concepts. An effective field theory is a quantum field theory that is not fundamental, but only valid over a limited range of energies or distances. The wide range of energies from the W-boson mass to the B-meson or charmed particle masses has made it possible to successfully use EFT and renormalization group methods to calculate the partial widths of heavy meson and baryon decays with high accuracy. The creation of more specific EFTs, such as HQET (heavy quark effective theory) and SCET (soft collinear effective theory) opened up a new possibility of describing and obtaining reliable predictions for a number of exclusive decays of heavy hadrons.

Also noteworthy is the huge success of the chiral perturbation theory ChPT (chiral perturbation theory), the oldest effective SM field theory, which has been widely used to obtain precision results for the dynamics of low-energy mesons. Thus, the adoption of an effective field theory philosophy for the SM has led to theoretical predictions that have reached a level of accuracy unimaginable twenty years ago. Equally impressive progress has been made in experiments at both low and high energies. It is expected that this search for increasingly higher accuracy, both in theory and experimentally, will continue in the hope of finding deviations from the SM, as indicated by a number of available experimental data.

From this point of view, it is very natural to consider the original formulation of the SM as an effective low-energy theory derived from a more fundamental theory by integrating heavy degrees of freedom, which leads to the generation of additional effective contact interactions between known SM fields. The effective Lagrangian thus obtained consists of a chain of local operators, each of which is characterized by a corresponding Wilson coefficient. The sequence of these operators is organized as series according to the increasing mass dimension of the operators. As usual for EFT, this construction is nonrenormalizable in the usual strict sense, since it involves an infinite number of coupling constants. However, it can be renormalized order by order in the energy expansion, as reflected in the operator expansion. Thus, considering the SM as an EFT can help in determining the properties of new physics and choosing future directions of research. The EFT approach does provide not only a systematic way to analyze experimental results, but also a valuable tool for correlating different observables, which gives a deeper understanding of where to look to discover the next level of our knowledge.

One of the key characteristics of SM is lepton flavor universatility (LFU ). This means that apart from differences in phase space and effects of helicity suppression, the amplitudes of electroweak interactions will be the same for all three generations of leptons. However, hints of deviations from LFU have been found in a number of heavy meson decays. The emerging experimental possibility of studying the properties of B mesons provided excellent conditions for studying the effects of new physics (NP) both at the theoretical and experimental levels. Any discrepancy between theoretical and experimental estimates may reflect a violation of lepton universality and thus open a clear path to new physics. The BABAR collaboration reported for the first time a discrepancy between the measurements of semileptonic B decays and the SM predictions for the ratios of the partial widths of the decay of a B meson into D mesons and a tauonic pair to the same decay, but with a muon pair in the final state. The Heavy Flavor Averaging Group (HFLAV) recently released the most recent global averages for 2022, analyzed using information from the collaboration between Belle, LHCb and BABAR, showing deviations in the 2-3σ levels. All of these measurements are indicative of a violation of LFU and are usually regarded as anomalies in *b*-*c* decays.

The NP contributions to the *b → c τ ν* transition imply that NP contributions to the *bb̄ → τ τ* transition are unavoidable given the assumption that neutrinos are exclusively left handed. Therefore, the ratio of lepton decays of bottomonium Υ(*bb*) into a tauonic pair to the corresponding decay into a muon (electron) pair can be used to test LFU.

An important aspect of the study of charmed physics is the study of D-meson decays with an open charm. If the decays of such mesons with spin zero are well studied both in theoretical approaches and in experiment (impressive results were obtained by the BES III collaboration), then the decays of vector D\* mesons with spin 1 are very difficult to study experimentally. Unlike pseudoscalar D-mesons, which decay only via weak interactions, their vector partners can decay via both strong and electromagnetic channels. Strong decay width measurement of the D\* meson opens a window into the nonperturbative regime of strong interaction physics, where the charmed quark is the heavier component of the meson. The line width provides experimental verification of spectroscopic models of D mesons and is related to the strong binding of the D\*Dπ system, characterized by the decay constant g(D\*Dπ) . In the limit of heavy quarks, which is not necessarily a good approximation for a charmed quark, this constant can be related to the universal interaction of heavy mesons with the pion. Since the B\*→Bπ decay is kinematically forbidden, it is impossible to directly measure the interaction constant g(B\*Bπ). However, the D and B systems can be coupled via the universal heavy meson-pion interaction constant, which makes it possible to calculate g(B\*Bπ) , which is necessary for the model-independent extraction of the matrix element of the Cabibbo-Kabayashi-Maskawa matrix |*Vub*|.

In 1964, Gell-Mann proposed the theory of quarks, the fundamental particles that make up matter. This was done on the basis of the observation that the successful eightfold way of classifying hadrons could be explained naturally by assuming that hadrons were composed of either a quark-antiquark pair or three quarks (or three antiquarks). In the same year, George Zweig arrived at the same conclusion independently by analyzing suppressed strong decays of the *φ*-meson. The existence of a fourth quark was discussed by a number of authors around 1964, but there was little evidence for its existence. His prediction is usually credited to Glashow-Iliopoulos-Maiani, who proposed the so-called GIM mechanism. This mechanism forbids flavor-changing neutral currents at the Lagrangian and tree diagram levels. This explains the suppression of decays due to weak interactions that change the strangeness by a factor of 2. The first particle containing a charmed quark and an antiquark was discovered in 1974 and was named the *J*/*ψ* meson.

In 2005, a new era in the study of doubly charmed baryons began when the SELEX collaboration reported the observation of a spin-1/2 state called the Ξ+*cc*-baryon with a mass of 3518  3 MeV. SELEX (Segmented Large Baryon Spectrometer) is a fixed target experiment at Fermilab. It has been suggested that this doubly charmed baryonic state has isospin ½ and consists of (*dcc*) quarks, and its isospin partner Ξ++*cc* has a quark composition (*ucc*). However, other collaborations (BABAR, Belle, and LHCb) found no evidence for the states Ξ+*cc* and Ξ++*cc* in the assumed mass region — 3500 MeV. In 2017, the LHCb collaboration discovered the doubly charmed state Ξ++*cc* in the invariant particle mass spectrum in the final state Λ+*c*  K−*π*+*π*+. Its lifetime was measured, and the mass of this state was equal to 3621.40  0.72  0.27  0.14 MeV, which is about 100 MeV more than the mass of the original doubly charmed baryon state (Ξ+*cc*) discovered by SELEX, making it unlikely that these two states are isospin partners.

Latest experimental data on the observation of decays Ξ+*cc*  Ξ+*cπ*−*π*+ and Ω+*cc*  Ξ+*c*K−*π*+ give only the upper bounds of their branchings. After the modernization of the LHC, it is planned to increase the collision energy to 14 TeV, improve the luminosity of the LHCb detector to 1033 cm−2s−1, the integral luminosity to 5 fb−1, which gives hope for the detection and measuring the fundamental decay modes of all doubly charmed baryons.

Charmed baryons usually decay when a c quark passes into a *d* or *s* quark. However, baryons, which contain both an *s* and a *c* quark, also have a special class of decay, the nonleptonic heavy flavor conservation decay that occurs via the *s* quark decay. In such decays, the weak interaction between light quarks can be well described by the short-range effective Hamiltonian, since the emitted pion has a small momentum due to the kinematic limit. Therefore, the width of such nonleptonic decay, which preserves heavy flavor, can be calculated theoretically, and experimental measurements can be used to test the synthesis of heavy quark theory and chiral symmetries. The well-known baryon Ξ0c consists of *c*-, *s*- and *d*-quarks and can decay as a result of the decay of an *s*-quark, while the *c*-quark acts as an observer, i.e. Ξ0c → Λ+*cπ*−. The first experimental measurement of branching Ξ0c → Λ+*c π*− was made by LHCb with a value of (0.55±0.02±0.18)%. The Belle collaboration confirmed this value by branching (0.54 ± 0.05 ± 0.05 ± 0.12)%.

The concept of multiquark states consisting of more than three quarks, put forward several decades ago, was first confirmed in 2003 when candidates for multiquark states were measured in the BES, BaBar and Belle experiments. The observed state in the invariant mass spectrum, *π*+ *π*−*J/ψ*, was the first observation of a charmonium-like state X(3872) that did not meet the expectations of existing quark models for any ordinary hadronic particle. The reason was its measured mass of 3872 MeV, which does not fit into the available predictions of spectroscopy models, as well as the difficulty of interpreting it as an excited charmonium *ψ*′: its possible decay into *ρJ/ψ* is strongly suppressed due to isospin violation. In subsequent years, other heavy quarkonia-like states X, Y, Z were discovered, where Y usually denotes an electrically neutral exotic (i.e., non-*c* ̄*c*) charmonium having quantum numbers *JPC* = 1− −, Z is used for charged states, and X denotes any cases other than Y and Z.

The relevance of the tasks stated in the project is beyond doubt both from a theoretical point of view and from the point of view of experiments conducted in this field of research on almost all modern facilities, such as LHC (CERN), Belle (KEK), BES III (Beijing Electron-Positron Collider) and the planned International Linear Collider (ILC) and Compact Linear Collider (CLIC) projects.

Precision spectroscopy of light atoms and molecules is one of the rapidly developing areas of modern physics. Modern methods of sympathetic cooling of atoms, molecules, and ions in traps, methods of quantum logic and quantum information create unique possibilities for high precision measurements of their spectra (with a relative precision of 10–11–10–12). From a theoretical point of view, the most suitable platform for such accurate calculations of spectra is nonrelativistic quantum electrodynamics, since the nonrelativistic Schrödinger equation already determines the dynamics of light atoms and molecules with good precision. At the same time, the methods of quantum field theory implemented in NRQED make it possible to construct a rigorous perturbation theory for calculating higher-order corrections in terms of the parameters *v/c~Zα*, *β=m/M*, where *v* is the velocity of electrons (muons) in atoms, *m/M* is the ratio masses of light particles to heavy ones in the molecular system. At the moment, the most accurate calculations of physical transitions have been obtained by our group at BLTP together with the scientists from the Castler-Brossel laboratory, ENS-Sorbonne Université (Paris). Thus, for molecular hydrogen ions H2+ and HD+, the values of vibrational transitions, which are measured in the experiment, have reached a relative accuracy of 7.5×10−12. Compared with recent experiments in Düsseldorf and Amsterdam, these calculations have become one of the most accurate tests of quantum electrodynamics.

The relevance of ongoing research is confirmed by the ever-expanding range of experiments on precision spectroscopy in the world. Here are just a few of them (the most interesting and promising from our point of view): ETH, Zurich, spectroscopy of forbidden H2+ transitions using quantum logic, target measurement accuracy 10−15; University of Düsseldorf, HD+ spectroscopy and creation of molecular clocks based on H2+ and HD+ ions. Current experiments at CERN, antiprotonic helium, and PSI (Switzerland), pion helium. In the latter, it is supposed to refine the mass *π*− to a relative precision of ~10−8, which can impose direct experimental restrictions on the mass of muon flavor antineutrinos. In the DAΦNE experiment, Frascati, Italy, it is planned to study the kaon helium atom (K−He+) in order to refine the kaon mass.

In addition to NRQED, there are a large number of computational methods based on the approach first formulated by Feinberg and Sucher in 1970 for the helium atom: "quantum electrodynamics for bound states of a system of many particles." These methods are still being developed in many scientific centers around the world, in particular, at St. Petersburg State University and PNPI. It should be noted that the areas of applicability of these methods do not overlap with NRQED, but rather complement each other. It is also necessary to mention the Logunov-Tavkhelidze quasipotential method for describing the relativistically invariant states of a system of particles in three-dimensional space, which has been successfully developed for a long time at the BLTP JINR, in Dubna.

Within the framework of this project, the following goals are outlined, which seem quite realistic to achieve, taking into account the developed methods and approaches.

– Investigate the possibility of violation of lepton universality in lepton decays of charmonium and bottomonium and their radial excitations.

– Obtain bounds on the values of the Wilson coefficients of the Standard Model Effective Theory (SMEFT) operators responsible for breaking the lepton versatility in the tauon sector.

– Calculate partial widths of strong and electromagnetic decays of vector D-mesons with an open charm.

– Calculate matrix elements and widths of nonleptonic two-particle decays of charmed baryons without changing the charm.

− Perform analysis of strong decays of the charmonium-like state Y(4230) in order to study the nature of its structure.

− Perform a theoretical analysis of the lepton decays of the B-meson with four leptons in the final state.

Within the framework of the project, it is planned to further develop the methods of nonrelativistic quantum electrodynamics, as well as the possibility of using a combined approach, when part of the contributions to the energy of a bound system is considered within the framework of QED, a total sum over all terms in powers of *α* or Z*α*. It is planned to include new terms in the general NRQED scheme, which will allow taking into account the contributions of light-by-light scattering, nontrivial centipede diagrams for one- and two-loop self-energy diagrams, and many others necessary to calculate corrections of the order of m*α*7 and higher.

An important point is the inclusion in the developed model of the phenomenological contributions associated with the effects of the finite size of the nucleus (nucleons, mesons), the polarizability of complex particles.

From a technical point of view, an important point is the development of precision methods for calculating a non-relativistic problem as a zero approximation. The most effective solution seems to be the use of variational methods. To this end, it is planned to further study various options for choosing and generating test functions, testing their effectiveness when applied to the nonrelativistic Schrödinger equation for bound states and to the Dirac equation of a bound electron in an external field.

All goals set are new in light of the work ahead to achieve them. When solving the tasks set, the methods of quantum field theory and effective theories of the Standard Model will be used. Hadron quantities such as decay constants and hadronic transition form factors will be calculated within the framework of the covariant quark model. Already obtained and published results using this technique give serious reasons that the goals set will be achieved. We hope that the implementation of the planned plans will make it possible to make significant progress in solving those physical problems that arise in modern experiments in precision physics.

Selected publications of employees of sector No. 2, Theory of Fundamental Interactions, BLTP

[1] M.A. Ivanov, D. Melikhov, “*Theoretical analysis of the leptonic decays B+ → ℓ+ℓ−ℓ+ ̄νℓ : Identical leptons in the final state*”, Phys. Rev. D **105**, 094038 (2022).

[2] Zhi-Da Bai, V.I. Korobov, Zong-Chao Yan, Ting-Yun Shi, and Zhen-Xiang Zhong, *Precision spectroscopy of the pionic helium-4.* Phys. Rev. Lett. **128**, 183001 (2022).

[3] В.И. Коробов, *Вариационные методы в квантовой задаче трех тел с кулоновским взаимодействием*. ЭЧАЯ **53**, 5-42 (2022).

[4] Gurjav Ganbold, Th. Gutsche, M.A. Ivanov, and V.E. Lyubovitskij. *Radiative transitions of charmonium states in the covariant confined quark model*. Phys. Rev. D **104**, 094048 (2021).

[5] S. Groote, M.A. Ivanov, J.G. Korner, V.E. Lyubovitskij, P. Santorelli, C.T. Tran, *Form-factor-independent test of lepton universality in semileptonic heavy meson and baryon decays*, Phys. Rev. D **103**, 093001 (2021).

[6] I. Kortunov, S. Alighanbari, M.G. Hansen, G.S. Giri, S. Schiller, and V.I. Korobov, *Proton-electron mass ratio by high-resolution optical spectroscopy of ion ensemble in the resolved-carrier regime*. Nature Physics **17**,569 (2021).

[7] V.I. Korobov and J.-Ph. Karr. *Rovibrational spin-averaged transitions in the hydrogen molecular ions*. Phys. Rev. A **104**, 032806 (2021).

[8] S. Alighanbari, G. S. Giri, F.L.Constantin, V.I. Korobov, S. Schiller, *High-precision test of three-body quantum physics in a molecular system and determination of fundamental constants*. Nature **581**, 152 (2020).

[9] Sayan Patra, M. Germann, J.-Ph. Karr, M. Haidar, L. Hilico, V.I. Korobov, F.M.J. Cozijn, K.S.E. Eikema, W. Ubachs, J.C.J. Koelemeij. *Proton-Electron Mass Ratio from Laser Spectroscopy of HD+ at the Part-Per-Trillion Level.* Science **369**, 1238 (2020).

[10] M.A. Ivanov, J.G. Korner, P. Santorelli and C.T. Tran, “*D\*-polarization as an additional constraint on New Physics in the b→c+τ+ντ transition*”, Particles **3**, no.1, 193-207 (2020).

[11] M.A.Ivanov, D. Melikhov and S. Simula, «*Form factors for B→ j1+j2 decays into two currents in QCD*», Phys. Rev. D **101**, 094022 (2020).

[12] V.I. Korobov, *Bethe logarithm for the helium atom*. Phys. Rev. A **100**, 012517 (2019).

[13] D.T. Aznabayev, A.K. Bekbaev, and V.I. Korobov, *Leading order relativistic corrections to the ro-vibrational spectrum of H2+ and HD+ molecular ions*. Phys. Rev. A **99**, 012501 (2019).

[14] S. Dubnicka, A.Z. Dubnickova, M.A. Ivanov, A. Liptaj, P. Santorelli and C.T. Tran, ``*Study of Bs→ℓ+ℓ−γ decays in covariant quark model*,” Physical Review D **99**, 014042 (2019).

[15] N.R. Soni, M.A. Ivanov, J.G. Korner, J.N. Pandya, P. Santorelli and C.T. Tran, *Semileptonic D(Ds)-meson decays in the light of recent data*, **Phys. Rev. D 98**, 114031 (2018)**.**

[15] S. Alighanbari, M.G. Hansen, S. Schiller, and V.I. Korobov, *Rotational spectroscopy of cold, trapped molecular ions in the Lamb-Dicke regime*. **Nature Physics 14**, 555 (2018).

**2.3 Estimated completion date**

2024-2028

**2.4 Participating JINR laboratories**

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Organization** | **Country** | **City** | **Participants** | **Type**  **of agreement** |
| Institute for Nuclear Research and Nuclear Energy BAN | Bulgaria | Sofia | D. Bakalov |  |
| Institute of Nuclear Physics | Kazakhstan | Almaty | A.K. Bekbaev |  |
| ENS-Sorbonne Université | France | Paris | Jean-Philippe Karr |  |
| Düsseldorf University | Germany | Düsseldorf | Stephan Schiller |  |
| Hainan University | China | Hainan | Zhen-Xiang Zhong |  |
| Imperial College | United Kingdom | London | Masaki Hori |  |
| Institute of Physics SAS | Slovak Republic | Bratislava | S. Dubnička  A. Liptaj |  |
| Comenius University | Slovak Republic | Bratislava | A. Z. Dubničková |  |
| Universitat Tübingen | Germany | Tübingen | V.E. Lyubovitskij |  |
| Napoli University | Italy | Napoli | P. Santorelli |  |
| University of  Technology | Vietnam | Ho Chi Minh | C.T. Tran |  |

**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 | 10 | 10 |
| 2. | engineers | 0 | 0 |
| 3. | specialists | ~~0~~ | ~~0~~ |
|  | **Total:** | **10** | **10** |

**3.2. Available manpower**

**3.2.1. JINR staff**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Category of personnel** | **Full name** | **Division** | **Position** | **Amount**  **of FTE** |
| 1. | research scientists | Korobov Vladimir Ivanovich | TFI | нач.сектора | 100% |
|  |  | Ivanov Mikhail Alexeevich | TFI | г.н.с. | 100% |
|  |  | Melikhov Dmitry Igorevich |  | в.н.с. | 50% |
|  |  | Gurjav Ganbold |  | в.н.с. | 100% |
|  |  | Issadykov Aidos Nurlanovich |  | с.н.с. | 100% |
|  |  | Surovtsev Jury Stepanovich |  | с.н.с. | 100% |
|  |  | Aznabaev Damir |  | н.с. | 100% |
|  |  | Tyulemissov Jomart |  | н.с. | 100% |
|  |  | Tyulemisova Akmaral |  | м.н.с. | 100% |
| 2. | engineers |  |  |  |  |
|  |  |  |  |  |  |
| 3. | specialists |  |  |  |  |
| 4. | technicians |  |  |  |  |
|  | **Total:** | **8 чел. − основное место работы**  **1 чел. − совместитель** |  |  | **8.5** |

**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 funded under the theme "Fundamental Interactions of Fields and Particles".

**4.1 Total estimated cost of the project/LRIP subproject**

The total cost estimate of the project (for the whole period, excluding salary).

The details are given in a separate table below.

**4.2 Extra funding sources**

Expected funding from partners/customers – a total estimate.

**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 | | 3rd year | | 4th year | | 5th year |
|  | | | International cooperation | | 100 | | 20 | | 20 | | 20 | | 20 | | 20 |
| 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)* | | 100 | | 20 | | 20 | | 20 | | 20 | | 20 | |
| **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

Phenomenology of strong interactions and precision physics

SHORT DESIGNATION OF THE PROJECT / SUBPROJECT OF THE LRIP

PROJECT/LRIP SUBPROJECT CODE

THEME / LRIP CODE

NAME OF THE PROJECT LEADER : V.I. Korobov, M.A. Ivanov

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | |
| 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 | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_  DATE |  |
| THEME / LRIP LEADER | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_  DATE |  |
| PROJECT / LRIP SUBPROJECT LEADER | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE |  |
| APPROVED BY THE PAC | \_\_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  NAME | \_\_\_\_\_\_\_\_\_  DATE | |