**Annex 1.**

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

***Large Research Infrastructure Project***

 **APPROVED**

 **JINR Vice-Director**

 **/**

 **" " 202 г.**

**THEME PROPOSAL FORM**

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

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

**1.1. Theme code / LRIP** (for extended themes) *–* *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 theme.*

 *01-3-1117-2024*

**1.2. Laboratory**

Bogoliubov Laboratory of Theoretical Physics

**1.3. Scientific field**

Theoretical Physics

**1.4.** **The title of the Theme / LRIP**

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

**1.5. Theme / LRIP Leader(s)**

I.G. Pirozhenko

**1.6. Rector of DIAS**

D.I. Kazakov

**2. Scientific case and theme organization**

**2.1. Annotation**

The Dubna International School of Modern Theoretical Physics (DIAS-Th) is a scientific and educational project that is successfully developing at the N.N. Bogolyubov Laboratory of Theoretical Physics since 2003.

The project is focused, first of all, on the training of senior students, graduate students and young scientists on research topics of the Laboratory of Theoretical Physics. Bogolyubov, priority scientific areas of JINR research and modern areas of physics. For this purpose, schools of various levels are regularly held for students, postgraduates and young scientists from the JINR Member States and other countries, and lectures are published. In addition, review lectures on problems of modern physics are organized for JINR staff. Both employees of JINR laboratories and internationally recognized scientists from Russian Federation and foreign scientific centers are involved in the project. The lectures given by the leading experts at DIAS schools stimulate the emergence of new research directions at BLTP. The project provides in-depth training in the field of modern theoretical and mathematical physics. To this end, the project participants cooperate with JINR University Center, as well as with the JINR-based Departments at Dubna State University, Moscow Institute of Physics and Technology, Moscow State University.

Secondly, the project is aimed at dissemination of scientific knowledge, namely, informing schoolchildren and people who are not professionally engaged in science about the achievements of modern theoretical physics, in particular, about current research in BLTP. In addition, one of the objectives of the project is to encourage young scientists to cooperate with BLTP JINR.

**2.2. Projects in the Theme / LRIP subprojects**

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

**2.3. Scientific case** (no more than 20 pages)

(aim, relevance and scientific novelty, methods and approaches, techniques, expected results, risks).

The scientific and educational project Dubna International Advanced School of Theoretical Physics was founded at the N.N. Bogolyubov Laboratory of Theoretical Physics on the initiative of Prof. A.T. Filippov in 2003. Over the past years, 17 winter schools and about 40 summer schools for students, graduate students and young scientists have been organized. More than 3 thousand people from Russian Federation, the JINR Member States and many other countries of the world took part in them.

In general, the main direction of activity within the framework of the project is in-depth training in the field of modern theoretical and mathematical physics. In particular, the aim of the project is to educate senior students, graduate students and young scientists in the areas of advanced research of the Bogiliubov Laboratory of Theoretical Physics and on JINR priority topics. One of the objectives of inviting the world's leading experts to lecture at DIAS schools is to stimulate the emergence of new areas of research at BLTP.

The project is also aimed at dissemination of scientific knowledge, namely, informing schoolchildren and people who are not professionally engaged in science about the achievements of modern theoretical physics, in particular, about current research in BLTP. In addition, one of the objectives of the project is to encourage young scientists to cooperate with BLTP JINR.

The scientific subject of the project reflects the directions of research at the Bogoliubov Laboratory of Theoretical Physics, and more generally, advanced research conducted and planned at JINR.
Within the framework of the DIAS project, one can single out several series of schools with a common direction.

In the field of nuclear physics, the series of schools "**Nuclear Theory and Astrophysical Applications**" (2005,2007,2011, 2014,2017) covers the following topics: nuclear structure and nuclear reactions, neutrinoless double beta decay, superfluidity in nuclei and neutron stars, terrestrial experiments for astrophysics, interaction of neutrinos with nuclei (nuclear matter), condensation and phase transitions in dense matter.

In the field of heavy ion physics at the schools "**Dense Matter in Heavy Ion Collisions and Astrophysics**" (2006), "**Matter under Extreme Conditions in Heavy-Ion Collisions and Astrophysics**" (2018), the equation of state and phase transitions in QCD are considered. Also discussed at these schools are the transport properties of dense quark-gluon matter, hadronization and freezing out in heavy ion collisions, astrophysics of compact stars and their mergers, modeling of dense quark-gluon matter, collisions of heavy ions and compact stars, dense matter in a strong electromagnetic field, experiments and monitoring programs. These schools are focused on the physics program of the NICA collider.

The series “**Hadron Structure, Hadronic Matter and Lattice QCD**” (2017, 2011) is devoted to the structure of hadrons and hadron spectroscopy. It gives theoretical introduction to gauge field theories on a lattice, including at nonzero temperature and baryon number density. Students have the opportunity to independently perform lattice simulations for some problems in hadron physics. Applications of lattice field theory beyond QCD are also considered. Much attention is also paid to the holographic approach to QCD.

A series of schools "**Physics of heavy quarks"** (2005,2008,2013,2015) evolved and changed its name to "**Quantum physics of limit states: from strong fields to heavy quarks**" (2019,2016). Target audience of these schools are graduate students and young scientists working in the high energy physics. The schools cover the main topics of heavy flavor physics, in particular, with a special focus on the latest results in heavy quark physics obtained in all four experimental groups at the LHC. (ATLAS, CMS, LHCb, ALICE) and at the B-factory in KEK. The second focus lies on the high-intensity frontier and extreme states of matter as probed by current and upcoming high-power laser and high-Z ion facilities all around the world. Leading experts in these fields are invited to give lectures devoted to theoretical predictions and analyses of experimental results

In the field of high-energy physics, we mention the schools “**Calculations for Modern and Future Colliders**” (2006,2009,2012,2015,2018). They are devoted to precision theoretical calculations for collider experiments. Participants of these schools get acquainted with the methods of multiloop calculations and resummation, computer codes for calculations in high energy physics, and modern methods for calculating scattering amplitudes. These schools also include lectures on physics beyond the Standard Model.

In the field of condensed matter physics, the series of schools "**Complex Systems and Advanced Materials**" is devoted to the following topical areas: superconductivity and devices; heterostructures; topological materials; graphene and 2D materials; Josephson nanostructures; quantum transport.

The School "**Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems**" was originally a project of the Czech group at BLTP, and has been held at JINR annually since 2013. Currently, the subject of this school is at the intersection of statistical mechanics, the theory of condensed matter, quantum field theory and modern mathematical physics. The lecture program touches upon the issues of stochastic systems, integrability, supersymmetry, quantum mechanics, quantum field methods of the condensed matter theory and a number of other issues of theoretical physics.

Schools held annually from 2003 to 2010 were devoted to modern mathematical physics. Initially, the topics of these schools were very broad and covered supersymmetry, supergravity, superstrings, noncommutative geometry, selected issues of gravity and cosmology, and integrable systems. Later schools of a narrower focus were held, such as "**Partition functions and automorphic forms**" (2018), "**Supersymmetry and integrability**" (2022).

In addition, the DIAS project hightlighted the cycle of schools "**Cosmology, strings and new physics**" (2013, 2016, 2019) and "**Actual cosmology**" (2021) with a program covering modern cosmology, inflation theory, problems of dark matter and dark energy, modified gravitaty models, modern astrophysical observations. The speakers at these schools were outstanding scientists: V.A. Rubakov (INR RAS), A.A. Starobinsky (Landau Institute of Physics and Technology), K.A. Postnov (GAISH MGU), Mukhanov (University of Munich), A.D. Dolgov (Novosibirsk and BLTP JINR), I.A. Arefiev (MI RAS).

A number of schools were organized jointly with other scientific centers: "**Perspective methods of modern theoretical physics: integrable and stochastic systems**" with the participation of the Czech Technical University in Prague, "**Statistical sums and automorphic forms**" (2018) together with the National Research University Higher School of Economics, "**Moscow International School of Physics**" (2022) together with LPI, NRU HSE, Skoltech. Over the past years, schools have repeatedly received financial support from UNESCO (ROSTE), the Russian Foundation for Basic Research, the Dynasty Foundation, the Helmholtz Association of German Research Centers (Helmholtz Gemeinschaft) and others.

Within the framework of the project "Dubna International School of Modern Theoretical Physics"

*in educational activities* it is supposed

- to continue organizing regular schools on JINR priority topics and modern scientific areas for schoolchildren, students, post-graduate students and young scientists from the JINR Member States and other countries;

- to continue preparing review lectures on problems of modern physics for JINR staff;

- to continue/renew cooperation with Russian Federationn and foreign scientific organizations, higher educational institutions in educational activities;

- to participate in the educational activities at the JINR-based departments of Moscow State University, MEPhI, MIPT, Dubna State University together with JINR University Center;

- to organize schools for students, graduate students and young scientists in cooperation with Moscow Institute of Physics and Technology, Yerevan Institute of Physics, etc.;

- to take part in international scientific and educational projects.

*In physics knowledge dissemination it is planned to collabotate*
- with other projects promoting popular science, such as Post Nauka;
- with Russian Federationn foundations (Russian Federationn Science Foundation, Federal Target Programs) and international foundations in organizing and conducting international schools for students, graduate students and young scientists.

*It is also planned*
- to support the DIAS-TH website;
- to provide video broadcasting of lectures;
- to record the video of the lectures, and to support the digital archive of DIAS-TH.

**2.4. Participating JINR laboratories**

BLTP, UC, LIT

**2.5. Participating countries, scientific and educational organisations:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  **Organization** | **Country** | **City** | **Participants** | **Type** **of agreement** |
| Yerevan Physics Institute  | Armenia | Yerevan | Manvelyan R. | Visit exchangeCollaboration |
| ГГБТУ | Belarus | Gomel | Solovtsova O.P.  | Collaboration |
| University | Germany | Muniсh | Mukhanov V. | Collaborations |
| ITEP | Russian Federation | Moscow | Morozov A.Yu | Visit exchange |
| MSU | Russian Federation | Moscow | Galtsov D. | Visit exchange Collaboration |
| Steklov Mathematical Inst, RAS | Russian Federation | Moscow | Aref’eva I.A. Sergeev A. | Visit exchange |
| Lebedev Physical Institute | Russian Federation | Moscow |  Barvinsky A. Vasiliev M.A.Danilov M.V.Pakhlov P. | Visit exchange |
| MIPT | Russian Federation | Долгопрудный | Akhmedov E.T.Musaev E.T. | Collaboration |
| NSU | Russian Federation | Novosibirsk | Dolgov A.D. | Visit exchange |
| Sternberg Astronomical Institute MSU | Russian Federation | Moscow | Postnov K.A.Toporensky A.V. | Visit exchange |
| SINP MSU | Russian Federation | Moscow | Boos E. Tetereva T.V. | Visit exchange |
|  NRU HSE | Russian Federation | Moscow | Gritsenko V. | Visit exchange |
|  IHEP | Russian Federation | Protvino | Bornyakov V.  | Visit exchange |
|  INR RAS | Russian Federation | Troitsk | Gorbunov D.S. Babichev E. | Visit exchange |
| Saint Petersburg State University | Russian Federation | Saint Petersburg | Yakovlev C.L.Yarevsky E.A.  | Visit exchange |
| Skoltex | Russian Federation | Skolkovo | Marshakov A.V. | Visit exchange |
| Saratov State University | Russian Federation | Saratov | Smolyansky S.A.  | Visit exchange |
| Kazan Federal University | Russian Federation | Kazan | Sushkov S.Popov А. | Visit exchange |
| Landau Institute for Theoretical Physics | Russian Federation | Chernogolovka | Belavin A.Kamenshchik A. Yu. | Visit exchange |
| Nis University  | Serbia | Nis | Djordjevic G. | Visit exchange |
| Technical University | Czech Republik | Prague | Burdic Ch. | Visit exchangeCollaboration |

**2.6. Key partners** *(those collaborators whose financial, infrastructural participation is substantial for the implementation of the research program on the theme. Example – JINR participation in the LHC experiments at CERN).*

**3. Manpower**

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

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Personnel category** | **JINR staff,** **FTE amount** | **JINR associated personnel,****FTE amount** |
| 1. | research scientists | 2.4 (6 part-time employees ) |  |
| 2. | engineers | 0.2 (1 part-time employees ) |  |
| 3. | specialists |  |  |
|  | **Total:** |  |  |

**3.2. Available manpower**

**3.2.1. JINR staff** (total number of participants)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Personnel category**  | **Division** | **Position** | **Amount** **FTE** |
| 1. | research scientists | BLTP | 3\*Leading researchers | 3\*0.4 |
|  |  | BLTP | Chief Researcher | 0.4 |
|  |  | BLTP | Senior Researcher | 0.4 |
|  |  | BLTP | Scientific Secretary | 0.4 |
| 2. | engineers | BLTP | Engineer in Electronics  | 0.2 |
|  | **Total:** |  |  | **2.6** |

**4. Financing**

**4.1. Total estimated cost of the theme / LRIP**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Items of expenditure** | **Cost** | **Expenditure per year****(thousands of the US dollars)** |
| **2024** | **2025** | **2026** | **2027** | **2028** |
| 1. | International cooperation |  | 7,9 | 8,5 | 9,0 | 9,4 | 9,7 |
| **TOTAL:** |  | **7,9** | **8,5** | **9,0** | **9,4** | **9,7** |

**4.2. Extra funding sources**

Expected extra funding from partners/customers (total for all projects).

**AGREED:**

**Chief Scientific Secretary Laboratory Director**

 **/\_\_\_\_\_\_\_ / /** D.I.Kazakov **/**

**" " 202\_г. " " 202\_г.**

**Head of BEPD Scientific Secretary of the Laboratory**

 **/\_\_\_\_\_\_\_ / /**A.V. Andreev**/**

**" " 202\_г. " " 202\_г.**

**Head of DSOA Laboratory Economist**

 **/\_\_\_\_\_\_\_ / /**I.N. Ivanova **/**

**" " 202\_ г. " " 202\_г.**

**Head of HRRMD Theme leader**

 **/\_\_\_\_\_\_\_ / /**I.G.Pirozhenko**/**

**" " 202\_г. " " 202\_г.**

**Project leader (project code) /**

**(LRIP subproject code)**

 **/**D.I.Kazakov**/**

 **“ “ 202\_г.**

**Project leader (project code) /**

**(LRIP subproject code)**

 /I.G.Pirozhenko/

 **“ “ 202\_г.**

***Annex 2.***

***Theme / Large Research Infrastructure Project Form***

 **APPROVED**

 **Director of Laboratory**

 **/ /**

 **" " 202 г.**

**REPORT ON THEME / LARGE RESEARCH INFRASTRUCTURE PROJECT**

**1. General information on the Theme / LRIP**

**1.1. Theme / LRIP code**

01-3-1117-2018/2023

**1.2. Laboratory**

Bogoliubov Laboratory of Theoretical Physics

**1.3. Scientific field**

**Theoretical Physics**

**1.4. Title of the Theme / LRIP**

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

**1.5. Theme / LRIP Leader**

I.G.Pirozhenko

**1.6. Projects in the Theme / LRIP subprojects**

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

**2. Scientific report on the Theme / LRIP**

**2.1. Annotation**

The Dubna International School of Modern Theoretical Physics (DIAS-Th) is a scientific and educational project aimed at training senior students, post-graduate students and young scientists on research topics of the Bogoliubov Laboratory of Theoretical Physics, priority scientific areas of JINR research and modern areas of physics. Within the project schools of various levels are regularly held for students, postgraduates and young scientists from the JINR Member States and other countries, and lectures are recorded and published. In addition, review lectures on problems of modern physics are organized for JINR staff.

**2.2. A detailed scientific report**

2.2.1. A description of the work carried out and the results obtained for all projects and activities of the theme.

The following schools were held

1. XV Winter School on Theoretical Physics «Complex Systems and Advanced Materials**»,** 28.01-01.02.2019
2. Helmholtz International Summer School «Quantum Field Theory at the Limits: from Strong Fields to Heavy Quarks» , July 22.07-2.08.2019
3. International School «Advanced Methods of Modern Theoretical Physics: Integrable and Stochatic Systems»**,**  July 28.07- 02.08.2019
4. Helmholtz International Summer School «Cosmology, Strings, New Physics», 04.08-17.08.2019
XVI DIAS-TH BLTP Winter School on Theoretical Physics «Actual Cosmology», 1-7.02.2021
5. XVII DIAS-TH Winter School "Supersymmetry and Integrability", 31.01-04.02.2022
6. Moscow International School of Physics, 24.07-02.08.2022
7. School on Physics of Quark-Gluon Matter, 20.03 -03.04. 2023
8. Advanced Methods of Modern Theoretical Physics: *Integrable and Stochatic Systems*, 23.07-28.07.2023 [in preparation]

Schools and seminars were attended by students, postgraduates and young scientists from the JINR Member States and other countries: Armenia, Belarus, Bulgaria, Germany, Iran, Spain, Italy, Kazakhstan, China, Poland, Romania, Serbia, Slovakia, Turkey, France, Czech Republic, Sweden, South Africa, Japan.

Lecturers and students at the schools represented numerous Russian universities and research centers: Moscow State University, NRU HSE, Moscow Institute of Physics and Technology, MEPhI, Skoltech, St. Petersburg State University, Samara State University, Saratov State University, Tomsk State Pedagigical University, Kazan Federal University, Far Eastern Federal University.

Lecture coursed were given by

G. Arutyunov (Hamburg University),E.Babichev(INR RAS), A.N. Baushev (BLTP JINR), D.Blaschke( Uni. Wroclaw) , E.Boos(MSU), I.Buchbinder (TSPU, Tomsk), P. Colangelo (INFN-Sezione di Bari), D.S.Gorbunov (INR RAS), A. D. Dolgov (ITEP and NSU) , A. Filippov (BLTP JINR), S. Fedoruk (BLTP JINR), A. Grozin (Budker Institute of Nuclear Physics), A. Kamenshchik (Bologna U. and Landau Inst.) , N. Krasnikov (INR), I.Logashenko(BINP), R. Manvelyan (Yerevan Physics Institute,Armenia), A.Marshakov(Skoltech), V. Mukhanov (Munich U.), E. Musaev (MIPT), V. Naumov (JINR) , N.M. Plakida (BLTP JINR), A.M. Povolotsky (BLTP JINR), Yu.M. Shukrinov (BLTP JINR), K. A. Postnov (SAI MSU), V.A. Rubakov В.А. (INR RAS), M. Shaposhnikov (Ecole Polytechnique, Lausanne), S. Shmatov(JINR), S. Sidorov (BLTP JINR), S. Smolyansky (Saratov State University), V.P. Spiridonov (BLTP JINR and NRU HSE) , A.A. Starobinsky (Landau Inst.), A.Toporensky (SAI MSU) , N.A.Tyurin (BLTP JINR), A. Vikman (FZU, Prague), M. Volkov (Univ. Tours), A. Westphal (DESY).

The Schools and Workshops were attended by students, post-graduates and young scientists from JINR Member States and other countries.

The Schools were supported by the Russian Foundation for Basic Research, JINR, NRE HSE, Helmholtz Association, DFG, and DAAD.

Full information on the Schools and Workshops is available on site: http://theor.jinr.ru/~diastp/diasth/

DIAS school materials are available at http://theor.jinr.ru/~diastp/diasth/
The video archive is regularly updated with recordings of lectures and seminars.

The schools were supported by JINR, NRU HSE, LPI, Skoltech, the Helmholtz Association (Germany). Full information about the schools and lectures is available on the website: http://theor.jinr.ru/~diastp/diasth/

Seminars and lectures for graduate students and students are regularly organized. An educational series of lectures on modern gravitational physics was organized at BLTP for JINR staff.

**3. International scientific and technical cooperation**

The countries, institutions and organizations actually involved.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  **Organization** | **Country** | **City** | **Participants** | **Type** **of agreement** |
| Yerevan Physics Institute  | Armenia | Yerevan | Manvelyan R. | Visit exchangeCollaboration |
| ГГБТУ | Belarus | Gomel | Solovtsova O.P.  | Collaboration |
| University | Germany | Muniсh | Mukhanov V. | Collaborations |
| ITEP | Russian Federation | Moscow | Morozov A.Yu | Visit exchange |
| MSU | Russian Federation | Moscow | Galtsov D. | Visit exchange Collaboration |
| Steklov Mathematical Inst, RAS | Russian Federation | Moscow | Aref’eva I.A. Sergeev A. | Visit exchange |
| Lebedev Physical Institute | Russian Federation | Moscow |  Barvinsky A. Vasiliev M.A.Danilov M.V.Pakhlov P. | Visit exchange |
| MIPT | Russian Federation | Долгопрудный | Akhmedov E.T.Musaev E.T. | Collaboration |
| NSU | Russian Federation | Novosibirsk | Dolgov A.D. | Visit exchange |
| Sternberg Astronomical Institute MSU | Russian Federation | Moscow | Postnov K.A.Toporensky A.V. | Visit exchange |
| SINP MSU | Russian Federation | Moscow | Boos E. Tetereva T.V. | Visit exchange |
|  NRU HSE | Russian Federation | Moscow | Gritsenko V. | Visit exchange |
|  IHEP | Russian Federation | Protvino | Bornyakov V.  | Visit exchange |
|  INR RAS | Russian Federation | Troitsk | Gorbunov D.S. Babichev E. | Visit exchange |
| Saint Petersburg State University | Russian Federation | Saint Petersburg | Yakovlev C.L.Yarevsky E.A.  | Visit exchange |
| Skoltex | Russian Federation | Skolkovo | Marshakov A.V. | Visit exchange |
| Saratov State University | Russian Federation | Saratov | Smolyansky S.A.  | Visit exchange |
| Kazan Federal University | Russian Federation | Kazan | Sushkov S.Popov А. | Visit exchange |
| Landau Institute for Theoretical Physics | Russian Federation | Chernogolovka | Belavin A.Kamenshchik A. Yu. | Visit exchange |
| Nis University  | Serbia | Nis | Djordjevic G. | Visit exchange |
| Technical University | Czech Republik | Prague | Burdic Ch. | Visit exchangeCollaboration |

**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,****FTE amount** | **JINR associated personnel,****FTE amount** |
| 1. | research scientists | 1.6 (4 part-time employees ) |  |
| 2. | engineers | 0.2 (1 part-time employees ) |  |
|  | **Total:** | **1.8** |  |

**Theme leader**

 **/**I.G. Pirozhenko**/**

**" " 202\_г.**