**Appendix 3.**

***Application form for opening or extending a Project***

**APPROVED**

**Director of the Institute**

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**“ “ \_\_\_\_\_\_\_2024**

**SCIENTIFIC AND TECHNICAL JUSTIFICATION**

**OPENING OR EXTENDING A PROJECT**

**IN THE TOPICAL PLAN FOR JINR RESEARCH   
AND INTERNATIONAL COOPERATION**

**1. General information about the project**

**1.1. Theme code**

07-5-1131-2017

**1.2. Project code**

07-5-1131-3-2025/2029

**1.3. Laboratory**

Flerov laboratory of Nuclear Reactions

**1.4. Field of research according to the structure of the TP**

07 –– Applied innovation activities

**1.5. Name of the project**

# High-sensitivity sensor based on molecular recognition for viruses detection

**1.5. Project leaders**

Nechaev A.N., Zavyalova E.G.

**1.6. Scientific leader of the project**

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**1.7. Deputy project leader**

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**2. Scientific rationale and organizational structure**

**2.1. Annotation**

The existing and future heavy-ion accelerator facilities at FLNR JINR offer unique opportunities for interdisciplinary research, especially for material science and nanotechnology. Swift heavy ions deposit enormous energy densities along their trajectory in matter, generating high aspect ratio nanoscopic damage trails known as ion tracks. Ion-track technology utilizes special ion track properties to produce nano- and microporous materials.

Track-etched membranes (TMs) are an example of the most advanced applications of ion-track technology. TMs offer distinct advantages over conventional membranes due to their precisely determined structure. Their pore size, shape, and density can be varied in a controllable manner so that a membrane with the required transport and retention characteristics can be produced. The modern trends in biology, medicine, environmental research, green energy harvesting, and other areas formulate demands for membranes with specific novel functionalities. These functionalities can be provided by tuning (setting) the geometry, morphology, and chemical properties of the TMs. The present Project will focus on the development of various functional TMs using the following approaches: (1) tuning the pore architecture; (2) composite structures; (3) hybrid structures; (4) targeted chemical and biochemical modification.

The final goals of the project are to find out the applications of nanocomposite and functional TMs with customized pore architecture and functionality for nanotechnology, biomedicine, sensor technologies, and membrane separation processes. Addressing the tasks of the Project will advance the scientific knowledge in radiation physics and chemistry of condensed matter and promote the development of novel types of functional TMs thanks to the coordination of experts working in interdisciplinary research fields. The expected project outcomes will include the implementation of new and elaboration of existing routes of the development of composite and hybrid TMs for targeted applications in modern branches of science and technology.

**2.2. Scientific rationale**

Stable work of veterinary services is the basis of the country's food security. Each outbreak of animal diseases leads to serious economic damage and poses threats not only to the development of animal husbandry, but also to the population: more than 80% of infectious diseases are common to humans and animals. Outbreaks of such dangerous diseases as African swine fever, Avian influenza, anthrax, foot-and-mouth disease, rabies, smallpox of sheep and goats are registered annually in the world, including Russia. One of the main activities of veterinary services is the prevention of animal diseases. In order to protect the population from diseases common to humans and animals, as well as the prevention and treatment of diseases of farm animals themselves, the veterinary service constantly conducts research and preventive work. At the same time, according to experts, ensuring biological safety, prevention and control of outbreaks of infectious diseases of animals, including those dangerous to humans, are hampered by several circumstances. First, this is the effectiveness of national veterinary services based on operational monitoring of the epizootic situation. Nowadays, the African swine fever in domestic swine has been recorded in many countries of the world, including the Russian Federation. Monitoring of African swine fever viruses (ASFV) are constantly being taken to prevent its spread to other zones, and agricultural complexes in all countries are suffering enormous losses. The causative agent of ASFV is a unique enveloped cytoplasmic DNA –containing arbovirus, which is the only member of the Asfarviridae family. Although previously it was believed that there was only one ASFV virus serotype, recent studies have classified 32 ASFV isolates into eight different serogroups based on the hemadsorption reaction. However, the genetic characterization of all ASFV virus isolates known to date has demonstrated 23 genotypes associated with geographical locations and numerous subgroups, illustrating the complexity of ASFV epizootiology. The genotype reflects the variability of a segment in a single gene and protein (VP-72) and is used mainly for molecular phylogenetic and purposes (for example, to determine the source of outbreaks). As far as is known, it does not define virulence or other disease parameters. According to WHO experts, ASFV is not dangerous to humans, but all measures to spread it are carried out in full to protect animals from death. No vaccine has been invented for such a disease, and every year the virus causes enormous damage to the economy, which in itself is also important. The disease appeared at the beginning of the last century, and since then no effective way to combat it has been found, and its potential threat to humans is quite palpable.

Although the virus does not cause clinical symptoms of infection in humans by penetrating the body, it would also be incorrect to say that it does not affect it at all. So far, there have been no recorded cases of ASFV in humans, but this does not mean that because of mutations it will not acquire pathogenic properties, and the immune system does not react to it in any way. The course of the disease has not been fully studied, as well as all possible forms of it. This is since sick animals are actively exterminated, preventing the infection from unfolding in full force. However, the presence of the virus in the body of people who have been in contact with sick animals can weaken the immune system. In addition, people who are actively engaged in agriculture and have been in contact with sick pigs have had cases of detection of antibodies to ASFV pathogens, which means that the immune system reacts to the virus, and it is possible that the infection is asymptomatic, and it is not a fact that it will always be so. Given the tendency of the virus genome to active mutations, there is a chance that over time it will acquire pathogenic properties, and then an epidemic of swine fever is possible among humans, and our immune system will not be able to reliably protect the body from aggression. Therefore, when outbreaks of ASFV are detected in any region, all necessary measures are taken to prevent its spread. The problem of ASFV monitoring has not been solved to date, and requires effective control methods of the ASFV virus, considering current trends in their detection, including novel sensors and membrane technologies.

**Track etched membranes for viruses’ rapid analyses and monitoring**

Nowadays track etched membranes are actively used for monitoring of microbiological pollution in environmental media. Creating fast, sensitive, and selective methods for detecting pathogens is one of the most critical public health tasks and guarantees for a national security. There is an increasing need for fast and cost-effective laboratory diagnosis of infectious diseases and identification of environmental microbiological contamination using the so-called “label-free” testing and biosensors based on fluorescence, Raman scattering, and mass spectrometry [1]. The development of rapid, sensitive, and selective methods for detecting pathogens, especially in cases requiring urgent medical care, remains a public health concern. Surface-enhanced Raman scattering (SERS) is a highly sensitive technique that allows for detecting molecules in very low concentrations. Using Raman-active tags or fluorophores significantly improves biosensor specificity and detection limits. A significant number of reports on the development of SERS biosensors are focused on using antibodies and aptamers that recognize the epitope of the surface of a biomolecule. Combining SERS with ultra- and microfiltration membranes capable of virus and bacteria retention can achieve high sensitivity and selectivity. An additional factor in the specificity of marker detection should be the use of bioaffinity interactions of the TM with immobilized antibodies or aptamers labeled with SERS reporters [2]. As a result, it is necessary to develop methods for obtaining membrane substrates SERS properties (SERS substrates) with desired properties required for successful bioaffinity interactions and plasmon resonance properties. It is, therefore, necessary to develop a new functional TM that combines silver, gold, or their alloy nanoparticles and modulated dielectric structures based on polyester nano-and microporous support, in which the dual plasma and dielectric resonances will be implemented, and a tremendous amplification of the electromagnetic field will be achieved. Some of the works carried out at the Center for Applied Physics have already proposed a biosensor based on polyethylene terephthalate TMs coated with aptamer-conjugated silver nanoparticles for the detection of influenza A and B viruses. Upon filtration with these multifunctional TMs with aptamers-silver nanoparticle conjugates, a high detection limit for influenza A virus in blood plasma was achieved [3]. There are no analogues of this kind produced industrially in the world. In the future, experimental substantiation of hypotheses and selection of optimal technical solutions will be carried out on the model detection of diagnostically significant antigens of adenoviruses or rotaviruses. The important Project aim is the development of scientific approaches and implementation of flow sensor technology based on multifunctional TMs, which allow significantly increased selectivity of analytical identification, especially epidemiologically dangerous substances such as African swine fever virus (ASFV), reduce the cost of its analysis due to the exclusion of numerous reagents, media, and specialized equipment, which will allow for performing analysis under field condition.

**Application of aptamers coated track etched membranes as antiviral agents against ASFV**

Several studies have demonstrated the potential of aptamers as antiviral agents against various viruses, including HIV, influenza, Zika virus, and others. Aptamers can be designed to inhibit viral entry into host cells, disrupt viral replication processes, or modulate host immune responses to enhance antiviral activity [4,5].

In the context of antiviral agents, aptamers have shown promise as potential therapeutics for many reasons, including:

1. Target specificity: Aptamers can be engineered to specifically target viral proteins or other molecules essential for viral replication or infection, minimizing off-target effects.
2. High affinity: Aptamers can be selected or engineered to have high affinity for their target molecules, allowing them to effectively interfere with viral replication or infectivity.
3. Ease of production: Aptamers can be produced through chemical synthesis, which is relatively straightforward and cost-effective compared to traditional antibody production methods [4,5].

While aptamers hold great promise as antiviral agents, further research and development are needed to optimize their efficacy, pharmacokinetics, and safety profiles for clinical use. However, they represent a promising class of therapeutics in the ongoing efforts to combat viral infections.

Besides using aptamers as direct antiviral agents, they can be used to coat artificial membranes for various purposes. By using aptamer-coated membranes, it is possible to selectively capture and remove target viruses from complex samples with high specificity and efficiency. This approach can be applied in various settings, including water treatment to remove waterborne viruses, purification of viral vectors used in gene therapy, or isolation of specific viruses from clinical samples for diagnostic purposes [6,7].

In this project we suggest studying two types of use of aptamer-coated membranes: (i) they function as antiviral filters by selectively capturing and removing target viruses from complex samples while allowing other components to pass through. This approach offers advantages such as high specificity, scalability, and cost-effectiveness, making it suitable for various applications, including water purification, bioprocessing, and biomedical research; (ii) aptamer-coated membranes may offer a rapid, sensitive, and specific method for virus diagnostics, allowing for the efficient capture and concentration of target viruses from clinical samples. This approach can be particularly useful in resource-limited settings or during outbreaks, where timely and accurate diagnosis is crucial for disease management and control. Antiviral and diagnostic properties of aptamers will be studied against ASFV.

It is known that a viral infection can cause a myriad of biological effects including inflammation and genotoxic and mutagenic effects in the host cells resulting in genetic instability and tissue damage. Therefore, the reduction of DNA damaging actions of viruses has practical importance. We expect that the application of track membranes with immobilized aptamers can significantly reduce the genotoxic and mutagenic effects of DNA and RNA viruses on the cells. Thus, DNA comet assay and quantitative analysis of cell-free DNA will be applied to evaluate the genotoxicity and the cytokinesis-block micronucleus assay for the assessment of mutagenicity of viruses.

DNA damage can also contribute to the pathogenesis of viruses through the triggering of apoptosis and the introduction of deleterious mutations that can also increase the risk of tumorigenesis. Therefore, the genotoxic effects of DNA and RNA viruses will be evaluated in host cells before and after the application of TMs. Thus, a cf-DNA analysis will be used as complementing biomarker for the evaluation of the potential of TMs to reduce the genotoxic and mutagenic effects of DNA and RNA viruses.

**Selection and characterization of aptamers**

CD2 and P54 proteins have been chosen as primary targets for the selection. The proteins are exposed on the outer surface of the virus promoting the recognition of the whole virus. The selection procedure will be conducted with DNA library with 40-nucleotide randomized region. The recombinant proteins will be immobilized on the column, and the aptamers with the highest retention time will be collected for the further evaluation. The aptamer-candidates will be sequenced using Illumina next generation sequencing or Nanopore sequencing approaches. The affinity of chemically synthesized aptamers will be evaluated using biolayer interferometry (Blitz) with recombinant protein immobilization on the amine-reactive sensor. Three aptamers with the highest affinity will be used for functional assays, including antiviral and virucidal activities. Also, the aptamers will be chemically synthesized with functional groups for track-etched membrane functionalization, including thiol groups and amino groups.

**Analysis of levels of DNA damage in cell cultures before and after the application of viruses and aptamers using comet assay**

Blood is the target sample for virus detection by PCR and virus isolation. Plasma separated during centrifugation can be used to detect antibodies using an indirect immunoperoxidase test (IPT) or the indirect method of fluorescent antibodies (nMFA). Since there is no vaccine, rapid and early detection of the disease is essential for the implementation of strict sanitary and biosafety measures to prevent the spread of the disease. ASF diagnosis means the identification of animals that are or have previously been infected with ASF. To obtain relevant information for the implementation of control and eradication programs, it is necessary to make a diagnosis, which includes the detection and identification of ASFV-specific antigens or DNA and antibodies.

A brief overview of laboratory diagnostic methods for African swine fever virus is presented below (Table 1).

**Table 1**. A brief overview of laboratory diagnostic methods for African swine fever virus

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Analysis for virus detection** | **Time** | **Sensitivity** | **Specificity** | **Sample type** | **Cost** | **Comments** |
| Polymerase chain reaction (PCR)\* | 5-6  hours | ХХХ | ХХ | Tissues, blood,  ticks or cell cultures | $$ | The most common contamination-sensitive method detects both live and dead viruses |
| Hemadsorption reaction  (RGAd) | 7-21  days | ХХ | ХХХ | Macrophages of pigs | $$$$ | THE GOLD STANDARD  It is used only in some reference laboratories |
| Direct Fluorescent Antibody (MFA) method | 75 min | ХХХ  (for early detection) | ХХХ | Cryoslice  Smear  Cell culture | $$$ | It is recommended if there is no PCR or no experience of conducting it. A fluorescent microscope is required.  Insufficiently sensitive one week after infection |
| ELISA | 3 hours | Х  (for early detection) | ХХ | Тissue serum | $ | Mostly not used. Insufficiently sensitive one week after infection |
| **Analysis for the detection of antibodies** | **Time** | **Sensitivity** | **Specificity** | **Sample type** | **Cost** | **Сomments** |
| ELISA\* | 3 hours | Х | Х | Serum | $ | Screening test.  In-lab and commercial kits are available |
| Immunoblotting | 3 hours | Х | Х | Serum | $$$$ | A confirmation test.  There are no commercial kits. |
| Indirect Fluorescent Antibody (nMFA) method | 4 hours | ХХХ | ХХ | Tissue exudates  Serum  or blood plasma | $$$ | A confirmation test.  There are no commercially available reagents.  A fluorescent microscope is required. |
| (\*) the most frequently used | | | | | | |

The alkaline version of the DNA comet assay will be applied for the evaluation of host DNA damage levels in cell cultures infected with ASFV. Simões et al. [8] demonstrated activation of DNA damage response pathways in cells infected with ASFV in vitro, while inhibition of ATR resulted in abrogation of viral p72 protein synthesis in vitro. Thus, inhibition of markers of genetic damage in infected cells can be a promising approach against ASFV.

Previously our group implemented a comet assay for the evaluation of DNA damage in cells infected with the ASFV [9]. We also analyzed the importance of markers of genetic damage in the host organism for the pathogenesis of other viral infections including COVID-19 [10.11].

In the current project, the following experimental groups of cells will be used: cells grown in standard conditions, cells grown in the medium filtered through TMs with aptamers, cells exposed to the ASFV, and cells grown in the medium that was previously exposed to ASFV and filtered through TMs with aptamers. Cells will be detached and processed for the analysis of DNA damage using comet assay. The images will be examined by fluorescence microscope (ZEISS, Germany). DNA damage will be assessed using Comet Assay IV software (Perceptive Instruments, UK). A total of 150 cells will be analyzed in three replicated slides for each sample. Percentage of DNA tail parameter of comets will be used to quantify the level of DNA damage.

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**Existing equipment and analysis programs:**

Center of applied physics FLNR (RUSSIA):

The following approaches and methodology will be used for the development of TMs sensors:

1. modern track etching technology to produce membranes with various structure characteristics, based on modern approaches and methods in terms of selection of polymer films, irradiation with heavy ion beams and physical and chemical treatment.;
2. chemical methods for surface modification using covalent bonding and polyelectrolyte adsorption;
3. PVD methods such as thermal vacuum evaporation and magnetron sputtering of metal and alloys;
4. nanofiber electrospinning techniques of polymers, including biopolymers;
5. structure investigations using atomic force microscopy, transmission electron microscopy, and X-ray diffraction;
6. IR-, UV-VIS spectroscopy, Raman-spectroscopy, real-time optical spectroscopy;

Institute of Molecular Biology of NAS RA (IMB) and Department of Genetics and Cytology of Yerevan State University (ARMENIA):

The Treatment of cells with the cultivation medium filtered through the TMs will be realized for the studies of viruses including:

1. laminar benches, qPCR, ELISA, centrifuges, freezers, and other equipment
2. comet assay will be carried out at the Department of Genetics and Cytology of Yerevan State University, which has fluorescent microscopes, MetaSystems, and Comet Assay IV systems for evaluation of DNA comets. Statistical analysis of DNA damage will be performed using SPSS19 and Statgraphics Centurion16 packages.

Chemistry department of Lomonosov Moscow State University (Russia):

Provides access to equipment for affine chromatography (Elveflow microfluidic device with Bambi compressor), analysis of affinity (Blitz interferometer with aminoreactive and streptavidin sensors, MOS-200 stopped-flow fluorimeter equipped with µSFM cuvette), aptamer folding estimation (MOS-500 circular dichroism spectrometer, Hitachi UV spectrometer).

**Expected results:**

The result of the Project is the scientific and technical groundwork for obtaining new engineered, functionalized TMs created during both theoretical and experimental studies. Depending on this, the values of the main (scientific/scientific and technical) characteristics of the results of the work are formulated as described below.

An important expected result of the work should be laboratory methods for obtaining engineered TMs modified using aptamers for ASFV monitoring. The experimental membrane samples obtained by this method will apply to biomimetic membranes and sensors. As a result of the work, the following experimental information will be determined:

1. Conditions of the irradiation process, such as beam intensity and geometry.
2. Conditions of the physicochemical treatment of the irradiated material before chemical treatment.
3. Conditions of the chemical etching and extraction of latent tracks conditions necessary to obtain the desired structure.
4. Methods of standardization and quality control of the designed TMs being developed.
5. Revealing antiviral properties of tested aptamers against ASFV in cell cultures.
6. Development of virucidal TMs with immobilized aptamers against ASFV.
7. Development of TMs with immobilized aptamers as sensors against ASFV.
8. Application of tested aptamers with virucidal capabilities attached to TMs based on the analysis of DNA damage in medium before and after filtering the viruses using comet assay.

The developed technology for obtaining functionalized TMs should ensure the production of high-performance and selective sorption microfiltration TMs for viruses monitoring. It is planned to create membranes with the silver- aptamers complex for ASFV determination. The presence on the market of multifunctional ASFV-sensitive TMs will positively impact on the viruses monitoring in agriculture and parasitology medicine. Methodological approaches to obtaining affinity membranes modified with silver and gold nanoparticles can be used to obtain biosensors and diagnostic kits for express analysis of the most significant social diseases (influenza, coronavirus, hepatitis, and oncology).

The solution of the set tasks of the Project will allow for maintaining the scientific priority and existing scientific directions in the technology field for the production and application of TMs, thanks to the coordination of specialists in interdisciplinary areas of knowledge. Obtaining new materials and devices for biomedical purposes using ion-track technologies will increase the potential for using accelerator technology and its contribution and role in solving socio-economic problems. The results of scientific research of the Project for the creation and production of a new TMs with controlled structural and surface properties can also be effectively used in implementing commercially attractive projects implemented within the framework of Russian an Armenian national programs in the field of nanotechnology and healthcare.

During the implementation of the project, it is planned 2 publications in Russian peer-reviewed journals and 5 publications in foreign journals indexed by WoS (Q1, Q2), defense of master's and PhD works.

**Risks:**

For the successful implementation of the Project and to reduce the risks, specialized and expensive support resources are required. The FLNR has the following leading scientific equipment and instruments: the newly created DC-140 accelerators of multiply charged ions with a specialized channel, diagnostics, and a chamber for irradiating polymer films with ions of different masses and energies; a complex of equipment for obtaining TMs, including sensitization units, chemical treatment units, and a metrological laboratory; standard purchased analytical equipment for determining the physicochemical properties of TMs. To modify the surface of TMs by PVD and CVD methods, the FLNR has devices for thermal and magnetron sputtering of thin films and a nanofiber electrospinning unit. Important to note, the prerequisites for the successful completion of work and the reduction of investment risks are that the FLNR has positive results of previous fundamental research and applied research, as well as scientific research in the following areas:

1. use of beams of high-energy ions for the modification of materials;
2. fabrication of TMs from various polymers;
3. investigation of the main structural and operational parameters of TMs;
4. elucidation of the physicochemical characteristics of TMs;
5. use of accompanying methods for modifying polymer films;
6. technical background in developing and creating stands and devices for pilot production of TMs.

FLNR team in the subject area are world-renowned specialists and experts with publications in highly cited scientific journals.

For the successful and low-risk implementation of the goals and objectives of the Project, it is advisable to involve specialists in various fields of knowledge, especially in the field of highly pure biological products technology and molecular biology. The following factors can be attributed to the severe risks of the Project:

1. deviation from the schedule of commissioning work on the DC-140 cyclotron;
2. failure and repair of crucial analytical equipment;
3. problems with ordering reagents;
4. difficulties with the delivery of imported reagents for molecular biological work.

**2.3. Estimated completion term**

2025 – 2028

|  |  |
| --- | --- |
| **Work stages** | **Work contents** |
| 2025 | 1. Selection of aptamers with highest affinity to ASFV. 2. Evaluation of genotoxic properties of selected aptamers in vitro using comet assay. 3. Track etched membrane gold and silver thin layers modification using magnetron sputtering |
| 2026 | 1. Evaluation of antiviral properties of non-genotoxic aptamers against ASFV in vitro before and after infection using comet assay. 2. Selection of aptamers with virucidal effects for further development of TMs with immobilized aptamers. 3. Modification of gold and silver nanolayers by ASFV specific aptamers. 4. Evaluation of antiviral properties of TMs with immobilized aptamers against ASFV. 5. Evaluation of Raman spectroscopy properties of TMs with immobilized aptamers against ASFV. |
| 2027 | 1. Comparative evaluation of tested aptamers antiviral properties against ASFV based on the analysis of DNA damage in cells incubated with aptamers using comet assay. 2. Development of protocol for ASFV analyses using SERS-active TM. 3. Application of selected TMs with immobilized aptamers with optimal virucidal capabilities attached to TMs. Estimation of their effectivity based on the analysis of DNA damage in medium before and after filtering the viruses using comet assay. |
| 2028 | 1. Application of selected TMs with immobilized aptamers with optimal virucidal properties attached to TMs. Evaluation of their effectiveness based on analysis of DNA damage in the medium before and after virus filtration using comet analysis. 2. Development of a protocol for monitoring the ASF virus in real time. |

**2.4. Participating laboratories of JINR**

DLNP

**2.4.1. MICC resource requirements**

Non

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **A country**  **or organization** | **City** | **Institute** | **Status** | **Participants** |
| Russia | Dubna | JINR | - | CAP FLNR |
| Armenia | Yerevan | ESU | - | Department of Genetics and Cytology |
| Armenia | Yerevan | NAS | - | IMB |
| Russia | Moscow | MSU | - | Department of chemistry |

**2.6. Co-executing organizations**

Non

**3. Staffing**

**3.1. Staffing requirements during the first year of implementation**

|  |  |  |  |
| --- | --- | --- | --- |
| **No. no.** | **Employee category** | **Key personnel Number of employees** | **Associate Personnel Number of employees** |
| 1. | scientists | 9 | - |
| 2. | engineers | 3 | - |
| 3. | specialists | - | - |
| 4. | employees | - | - |
| 5. | workers | - | - |
| **Total:** | | **12** | - |

**4. Financial support**

**4.1. Full estimated cost of the project**

250 kUSD

**4.2. Extrabudgetary sources of funding**

Non

Project Leaders: Nechaev A.N. / /

# Zavyalova E.G. / /

Date of submission of the project to the DNOD \_\_\_\_\_\_\_\_\_

Date of the decision of the Scientific and Technical Council of the Laboratory,  
document number \_\_\_\_\_\_\_\_\_

Year of start of the project –– 2025

**Proposed schedule and necessary resources   
for the implementation of the Project**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Names of costs, resources,**  **funding sources** | | | **Cost (thousand dollars) of resource requirements** | **Price,**  **distribution by year** | | | | |
| 1 year | 2 year | 3 year | 4 year | 5 year |
|  | | International cooperation (ISTС) | 25 | 5 | 5 | 5 | 5 | 5 |
| Materials | 75 | 15 | 15 | 15 | 15 | 15 |
| Third party equipment and services (commissioning works) | - |  |  |  |  |  |
| Commissioning works | - |  |  |  |  |  |
| Services of research organizations | 150 | 30 | 30 | 30 | 30 | 30 |
| Purchasing software | - |  |  |  |  |  |
| Design/Build | - |  |  |  |  |  |
| Service costs (*are planned in case of direct affiliation with the project)* | - |  |  |  |  |  |
| **Required Resources** | **Working hour** | Resources |  |  |  |  |  |  |
| * FTE amount | 12 | 12 | 12 | 12 | 12 | 12 |
| * Accelerator FLNR | 12,5 | 12,5 | 12,5 | 12,5 | 12,5 | 12,5 |
| * reactor | - |  |  |  |  |  |
| **Sources of financing** | **Budget resources** | JINR budget (budget items) | 250 | 50 | 50 | 50 | 50 | 50 |
| **Off-budget (additional estimate)** | Contributions from co-executors  Funds under contracts with customers  Other sources of funding | - |  |  |  |  |  |

Project Leader Nechaev A.N. / /

Laboratory Economist Mamonova T.V. / /

**PROJECT APPROVAL SHEET**

Name of the Project: "High-sensitivity sensor based on molecular recognition for viruses detection"

Project code: 07-5-1131-3-2025/2029

Theme code: 07-5-1131-2017

Full name of the Project Leader: Nechaev Alexander Nikolaevich

Zavyalova Elena Gennadievna

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| **AGREED** |  |  |  |
| **JINR Vice-Director** | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |
|  |  |  |  |
| **Chief Scientific Secretary  of the Institute** | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |
|  |  |  |  |
| **Chief Engineer of the Institute** | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |
| **Head of BEPD** | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |
| **Head of HRRMD** | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |
|  |  |  |  |
| **Scientific Secretary of the Laboratory** | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |
| **Theme Leader**  **Project leaders** | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |
|  | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |
|  | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |

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| --- | --- | --- | --- |
| Approved by the PAC for\_\_\_\_\_\_\_\_\_\_\_\_  (direction) | \_\_\_\_\_\_\_\_\_\_  SIGNATURE | \_\_\_\_\_\_\_\_\_  Full name | \_\_\_\_\_\_\_\_\_  DATE |