**Annex 3.**

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

***Sub-project of LRIP***

 **APPROVED**

 **JINR DIRECTOR**

 **/**

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**SCIENTIFIC AND TECHNICAL REASONING FOR THE OPENING / RENEWAL**

**OF PROJECT/SUB-PROJECT OF LARGE RESEARCH INFRASTRUCTURE PROJECT**

**IN RESEARCH AREA WITHIN THE TOPICAL PLAN FOR JINR RESEARCH**

**1. General information on the project/subproject of the large research infrastructure project**

**(hereinafter LRIP)**

* 1. **Theme code / LRIP** (for renewable 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 topic.*

04-2-1126-2015

**1.2 Project/sub-project of a MIP code** (for renewed themes)

**1.3 Laboratory**

DLNP

**1.4 Scientific field**

**Accelerator / Detector R&D, Applied research.**

**1.5 The name of the Project/subproject of the LRIP**

**Development of experimental techniques and applied research with slow monochromatic positron beams (PAS)**

**1.6 Project/ sub-project of the LRIP Leader(s)**

**A. A. Sidorin**

**1.7 Project/sub-project of the LRIP Deputy Leader(s) (scientific supervisor of the project/sub-project of the LRIP)**

**I. N. Meshkov**

**2 Scientific rationale and organisational structure**

**2.1 Annotation**

To study the structure of various materials and defects that occur under various physical influences (aging, external loads, radiation exposure, etc.), high-precision methods are required that can distinguish inhomogeneities of the crystal structure at the nanometer level. One of these methods is positron annihilation spectroscopy (PAS). This method is sensitive to detecting various (so-called "open-volume") defects ranging in size from 0.1 to 1 nm with a minimum concentration of up to 10-7 cm-3. The PAS method has 4 orders of magnitude better spatial resolution compared to a transmission electron microscope.

Applied research in the field of solid state by PAS methods and the development of experimental techniques using these methods are the goal of the project. To study defects in materials, the Doppler broadening of the annihilation line (DBAL) method is used, implemented on a flow of slow monochromatic positrons. The DBAL spectrometer is made according to the standard scheme. The Positron Annihilation Lifetime Spectroscopy (PALS) method implemented on a stand-alone 22Na source is also used. To develop the experimental base, the PALS method is being implemented on a flow of slow monochromatic positrons. The team proposed an original version of this method, based on the formation of an ordered flow of slow positrons.

**2.2 Scientific justification (**purpose, relevance and scientific novelty, methods and approaches, methodologies, expected results, risks)

**The main objectives of the project are:**

1) study of the defect formation in materials as a result of various physical influences;

2) study of materials for detectors;

3) development of the existing experimental base.

1) Research by PAS methods can be continued with existing measuring equipment. The main areas of research for this period are the study of defect formation in materials that are used in nuclear power. These materials include various types of ceramics and refractory metals.

2) Work is also underway in the field of studying new methods of processing and obtaining materials for various types of detectors. Research in this area by the PAS method began not so long ago and requires further development, being one of the promising areas within the framework of the project.

3) The development of the experimental base will be carried out in several directions:

a. Improvement of the DBAL spectrometer by adding into the measurement scheme the possibility of registering the coincidence of two annihilation gamma quanta. In the standard measurement scheme (one detector), the peak-to-background ratio is usually ≈ 30 to 1. The peak-to-background ratio can be improved by more than two orders of magnitude using the method of detecting the coincidence of two gamma quanta.

b. Completion of the positron ordering system and commissioning of the PALS spectrometer on a monochromatic positron beam.

PALS spectroscopy serves as a unique tool for characterizing structural defects and cavities in materials. The lifetime of a positron is related to the size of the cavities into which the positron is trapped, and weakly depends on the material surrounding the cavity. Nevertheless, the quantitative determination of the positron lifetime is difficult when considering thin films or layered structures with a submicron layer thickness that have high technological significance. This is because the energy of positrons from the source lies in a wide range from units of eV to 1.2 MeV. The currently developed setups overcome this limitation by using monoenergetic positron beams, which makes it possible to conduct studies of thin films depending on the depth on a scale from nanometers to micrometers. There are only a few such installations in the world.

c. Development of the ion etching technique on the created etching system and its application for the study of thin-film multilayer materials. The installed ion source makes it possible to irradiate samples with argon ions with an energy of up to 5 keV and study the distribution of defects with the best depth resolution. The currently operated positron beam allows the use of positrons with energies up to 40 keV. If the surface of the sample consists of several films with a total thickness of over several hundred nanometers, then only the uppermost of them can be studied. The use of an ion source makes it possible to spray the target by ion etching. Studies have shown that with the gradual removal of the surface atoms of the sample by argon ions, the defective structure of the studied area of the sample does not change.

d. When preparing samples for research, it is required to carry out the procedure of "zeroing" defects in samples from mechanical processing. The matter of the procedure is to heat the prepared sample to a temperature equal to about 2/3 of the melting point. Heating is carried out in a vacuum. The problem of high-temperature vacuum heating arises, which can be solved by heating samples with an electron beam. The available technical capabilities allow us to implement this heating method. The first experiments of high temperature annealing at the Recuperator stand showed the viability of such a method.

**Risks**

Difficulties in accessing to equipment produced by foreign companies is the main risk of the project. Risks are also associated with the possible departure of a foreign highly qualified person.

**Expected results.**

The implementation of the program presented in this project will bring the complex to a qualitatively new level, create new opportunities for experimental research on ordered monochromatic positron beams, and allow to create a unique setup in Russia.

**2.3 Estimated completion date**

2024-2028

**2.4 Participating JINR laboratories**

LHEP, LNP, LNR

**2.4.1** **MICC resource requirements**

|  |  |
| --- | --- |
| **Computing resources** | **Distribution by year** |
| 1st year | 2nd year  | 3rd year | 4th year  | 5th year  |
| Data storage (TB)- EOS- Ribbons | 0 | 0 | 0 | 0 | 0 |
| Tier 1 (core-hour) | 0 | 0 | 0 | 0 | 0 |
| Tier 2 (core-hour) | 0 | 0 | 0 | 0 | 0 |
| SC Talker (core-hour)- CPU- GPU | 0 | 0 | 0 | 0 | 0 |
| Clouds (CPU cores) | 0 | 0 | 0 | 0 | 0 |

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  **Organisation** | **Country** | **City** | **Participants** | **Type** **of agreement** |
| Vietnam Atomic Energy Institute | Vietnam | Ho Chi Minh city | Nguyen Vu Minh Trung | Cooperation agreement, collaborative work |
| Institute of Radiation Problems, Ministry of Science and Education Republic of Azerbaijan | Azerbaijan | Baku | Samedov Samir Faig | Cooperation agreement, collaborative work |
| The Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences | Bulgaria | Sophia | Popov E. P. | Collaborative work |
| Northern (Arctic) Federal University named after M.V. Lomonosov | Russia | Arkhangelsk | Eseev M. K. | Collaborative work |
| Tomsk Polytechnic University | Russia | Tomsk | Laptev R. S. | Collaborative work |

**2.6. Co-executing organisations** *(those collaborating organisations/partners without whose financial, infrastructural participation the implementation of the research programme is impossible. An example is JINR's participation in the LHC experiments at CERN).*

**3. Staffing**

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

|  |  |  |  |
| --- | --- | --- | --- |
| **№№****n/a** | **Category****employee** | **Core staff,** **Amount of FTE** | **Associated** **Personnel****Amount of FTE** |
| 1. | scientific staff | 2,25 | 0,5 |
| 2. | engineers | 4 |  |
| 3. | professionals |  |  |
| 4. | employees |  |  |
| 5. | workers |  |  |
|  | **Total:** | **6,25** | **0,5** |

**3.2. Human resources available**

**3.2.1. JINR core staff**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **№№п/a** | **Category of employees** | **NAME** | **Division** | **Position** | **Amount** **of FTE** |
| 1. | scientific staff | Meshkov I. N. | VBLHEP, Administration | Chief researcher |  |
| Kobets V. V*.* | VBLHEP, Sector №5, Linear accelerators | Head of the Sector |  |
| Popov E. P. | DLNP, Department of Research and Innovation, SPS | Senior Researcher |  |
| Samedov S. F. | DLNP, Department of Research and Innovation, SPS | Senior Researcher |  |
| Nguyen Vu Minh Trung | DLNP, Department of Research and Innovation, SPS | Junior researcher |  |
| Rudakov A. Yu. | DLNP, Department of Research and Innovation, SPS | Researcher |  |
| 2. | engineers | Orlov O. S. | DLNP, Department of Research and Innovation, SPS | Engineer |  |
| Hilinov V. I. | DLNP, Department of Research and Innovation, SPS | Engineer |  |
| Sidorin A. A, | DLNP, Department of Research and Innovation, SPS | Engineer / Head of the Sector |  |
| Akhmanova E. V. | DLNP, Department of Research and Innovation, SPS | Senior Engineer |  |
| 3. | professionals |  |  |  |  |
| 4. | workers |  |  |  |  |
|  | **Total:**  |  |  |  | **6,25** |

**3.2.2. JINR associated personnel**

|  |  |  |  |
| --- | --- | --- | --- |
| **№№п/a** | **Category of employees** | **Partner organisation** | **Amount of FTE** |
| 1. | Scientific employees | Vietnam Atomic Energy Institute | 0,5 |
| 2. | engineers |  |  |
| 3. | professionals |  |  |
| 4. | workers |  |  |
|  | **Total:**  |  | **0,5** |

**4. Financial support**

**4.1 Total estimated cost of the project/sub-project of the LRIP -** 260 000 USD

Forecast of the total estimated cost (specify cumulatively for the whole period, excluding FPC).

The details are given in a separate form.

**4.2 Extrabudgetary funding sources**

Estimated funding from co-executors/customers - total.

Grant of the Plenipotentiary representative of the Government of the Socialist Republic of Vietnam 10 thousand dollars per year

**Project (****sub-project of the LRIP) Leader** \_\_\_\_\_\_\_\_\_\_/\_\_\_Sidorin A. A.\_\_\_\_\_\_\_\_/

Date of submission of the project (sub-project of the LRIP) to DSOA: \_\_\_\_\_\_\_\_\_

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

Year of the project (subproject of the LRIP) opening: \_2015\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(for renewable projects) -- Project start year: \_\_2015\_\_\_\_\_

**Schedule proposal and resources required for the implementation
of the Project / Sub-project of the LRIP**

|  |  |  |
| --- | --- | --- |
| **Names of costs, resources,** **sources of funding** | **Cost (thousands** **of dollars)****resource requirements** | **Cost,** **distribution by year**  |
| 1st year | 2nd year  | 3rd year | 4th year  | 5th year  |
|  | International cooperation (IC) | 25 | 5 | 5 | 5 | 5 | 5 |
| Materials  | 25 | 5 | 5 | 5 | 5 | 5 |
| Equipment and third-party services (commissioning) | 160 | 40 | 30 | 40 | 25 | 25 |
| Commissioning work | 0 | 0 | 0 | 0 | 0 | 0 |
| Services of research organisations  | 0 | 0 | 0 | 0 | 0 | 0 |
| Acquisition of software | 0 | 0 | 0 | 0 | 0 | 0 |
| Design/construction | 0 | 0 | 0 | 0 | 0 | 0 |
| Service costs (*planned in case of direct project affiliation)* | 0 | 0 | 0 | 0 | 0 | 0 |
| **Resources required** | **Normo-hours** | Resources | 0 | 0 | 0 | 0 | 0 | 0 |
| * the amount of FTE,
 | 0 | 0 | 0 | 0 | 0 | 0 |
| * accelerator/installation,
 | 0 | 0 | 0 | 0 | 0 | 0 |
| * reactor,….
 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Sources of funding** | **Budgetary resources** | JINR budget *(budget items)* | 210 | 50 | 40 | 50 | 35 | 35 |
| **Extrabudgetary (supplementary estimates)** | Contributions by co-contractors Funds under contracts with customersOther sources of funding | 50 | 10 | 10 | 10 | 10 | 10 |

Project (sub-project of the LRIP) Leader\_\_\_\_\_\_\_\_\_/\_\_\_\_\_Sidorin A. A.\_\_\_\_\_\_/

Laboratory Economist \_\_\_\_\_\_\_\_\_/\_\_\_\_Usova G. A.\_\_\_\_\_\_\_\_\_\_\_\_/

**APPROVAL SHEET FOR PROJECT / SUBPROJECT OF THE LRIP**

NAME OF THE PROJECT/SUBPROJECT OF THE LRIP

DESIGNATION OF THE PROJECT / SUBPROJECT OF THE LRIP

PROJECT/SUBPROJECT OF THE LRIP CODE

THEME / LRIP CODE

NAME OF THE PROJECT/ SUBPROJECT OF THE MIP 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 SECRETARYTHEME / MIP LEADER | \_\_\_\_\_\_\_\_\_SIGNATURE | \_\_\_\_\_\_\_\_\_NAME | \_\_\_\_\_\_\_\_\_DATE |  |
| PROJECT / SUBPROJECT OF THE LRIP LEADER | \_\_\_\_\_\_\_\_\_\_SIGNATURE | \_\_\_\_\_\_\_\_\_NAME | \_\_\_\_\_\_\_\_\_DATE |  |
|  |  |  |  |  |
| APPROVED BY THE PAC  | \_\_\_\_\_\_\_\_\_\_\_SIGNATURE | \_\_\_\_\_\_\_\_\_NAME | \_\_\_\_\_\_\_\_\_DATE |