Form № 21

APPROVED BY
JINR Vice Director

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SCIENTIFIC AND TECHNICAL JUSTIFICATION FOR OPENING A NEW THEME OR FOR EXTENDING THEME
to be included in the
TOPICAL PLAN FOR JINR RESEARCH FOR 2020–2022

Theme code **Frank Laboratory of Neutron Physics**

Department of Condensed Matter Research and Developments

Research area: 04 – Condensed Matter Physics; Radiation and Radiobiological Research

Theme title: Development of the SOLCRYS structural research laboratory at SOLARIS synchrotron

Theme leader: N. Kučerka

Abstract
The condensed matter research is one of the pillars of the research at the Joint Institute for Nuclear Research. It combines the theoretical approaches of the Bogolyubov Laboratory of Theoretical Physics, applied research of the nanomaterials in the Flerov Laboratory of Nuclear Reactions, and for the most part the nuclear methods utilizing the research reactor at the Frank Laboratory of Neutron Physics. Especially the latter have accumulated rich experiences in the materials science research, including hard and soft condensed matter. It is however important to acknowledge also the needs of additionally employed X-ray scattering techniques. Both neutron and X-ray scattering are capable of providing dynamical and structural information, although the principal differences between the two exist in their interactions with matter. Highly beneficial approach of utilizing the two probes in a complementary way then gives the scattering-based approaches a distinct advantage.

Scattering-based investigation methods have over the decades proven to be some of the most widely used techniques in the studies of new materials (catalysts, polymers, etc.), nanomaterials (nanoparticles, nanocomposites, etc.), materials at extreme conditions (superconductors, perovskites, etc.), and biomaterials (proteins, DNA, etc.). The results of these studies lend themselves in the first place to expanding our basic understanding in the areas of condensed matter physics. Consequently however, the utilization of such results ultimately finds its place also within the various fields of industrial applications (engineering, constructions, chemistry, pharmacy, etc.).

Recently initiated collaboration between JINR and Polish National Synchrotron Radiation Centre SOLARIS presents a unique opportunity to acquire an access to the modern synchrotron source. A new laboratory for structural research utilizing synchrotron X-rays at SOLARIS is proposed to be built by JINR that will guarantee a direct access for our scientists (including all the member states). A concept of the new laboratory is being developed by the experts from both institutes within the framework of their scientific

programs. The three measuring stations that will allow accomplishing this goal have been identified and selected for the construction as:

- Macromolecular X-ray Crystallography
  dedicated to the diffraction studies of single crystals, which should operate in the full power range using photons in the energy range 6-25 keV. By using the full range of available power, it will be possible not only to record diffraction data in experiments based on the MAD technique, but also performing measurements of X-ray absorption (XAS). Studies at this station will include standard protein crystallography (including MAD) in both direct and remote modes.

- Small-Angle X-ray Scattering
  equipped with high-end X-ray optics allowing small-angle X-ray scattering studies of solutions of biomacromolecules (BioSAXS) or nanoparticle suspensions, as well as SAXS investigations of novel nanomaterials (polymer systems, molecular sieves, nanocomposites, liquid crystals etc.). Studies at this station will include wide range of biological objects including: intrinsically disordered proteins, globular and membrane proteins, macromolecular complexes, viruses and virus-like particles, biological membranes, liposomes, nucleic acids and their complexes with proteins or drug delivery systems.

- Powder Diffraction
  equipped with powder diffractometer with high-quality line or surface detector. The whole system will allow the measurement of diffraction in a wide temperature range (60-1500K) and pressures.

List of activities

1. In order to organize the SOLCRYS laboratory, the extension of the existing experimental hall will be necessary. The extended part of the building will contain the endstations of the crystallographic beamline as well as the laboratory of samples preparation.
2. Elaboration and development of the Technical Infrastructure within a scope necessary to install and properly operate the research equipment of the SOLCRYS laboratory.
3. Design, purchase and installation of the Research Infrastructure including:
   a. design, purchase and installation of a superconducting wiggler as a radiation source in the X-ray range with an upper photon energy at least 20 keV
   b. design, purchase and installation of a research line for diffraction studies, including:
      i. the vacuum system separating the synchrotron and the line – the so-called front end
      ii. the infrastructure of the line consisting of vacuum systems, beam guidance and control systems, optics and monochromators
   c. design, purchase and installation of a measuring station for diffraction studies
   d. construction of measuring stations for small-angle X-ray scattering (SAXS) and wide-angle X-ray scattering (WAXS) studies
   e. design and assembly of control systems as well as that of data acquisition and storage systems
   f. construction of samples preparation facilities.

Results expected upon completion of the theme

1. Technical infrastructure for the SOLCRYS laboratory.
2. Superconducting wiggler as a radiation source.
3. X-ray beamline for diffraction studies.
4. X-ray beamline for small-angle and wide-angle X-ray scattering studies.
5. Facilities for sample preparation.
6. Access to the constructed SOLCRYS laboratory for JINR scientists (including all the member states).

Participants from JINR

Laboratory	№№	Name, Surname	№№	Name, Surname
FLNP		Kucerka Norbert		
		Kuklin Alexander		
		Lukin Eugen		

Participating countries, institutes and organizations

Country or Organization	City	Institute or Laboratory	Participants Name, Surname	Status
Poland	Krakow	SOLARIS	Marek Stankiewicz Jacek Szade	Collaboration Exchange visits
Poland	Poznan	A. Mickiewicz University	Maciej Kozak	Collaboration Exchange visits
Russia	Novosibirsk	Budker Institute of Nuclear Physics	Nikolai Mezentsev Vitaliy Shkaruba	Contract
Republic of Belarus	Minsk	Belarusian State University	Sergey Maksimenko Polina Kuzhir	Collaboration Exchange visits

Time frame of the theme
January 2020 – December 2022

Total estimated cost of the theme

№№	Activities	Total cost	Costs per years (thousand USD)		
			1st year	2nd year	3rd year
1.	Equipment	9,061.2	3,020.4	3,020.4	3,020.4
	Total	**9,061.2**	**3,020.4**	**3,020.4**	**3,020.4**

Other financing sources

Cost estimates for the theme

№№ of items	Budget items	Total 2020–2022	Including 2020
6	Equipment	9,061.2	3,020.4
	Total	**9,061.2**	**3,020.4**

AGREED:

JINR Chief Scientific Secretary

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Laboratory Director

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Head of Planning and Finance Department

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Laboratory Scientific Secretary

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Head of Science Organization Department

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Laboratory Economist

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Theme leader

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