

Kurchatov complex for synchrotron - neutron investigations (KCSNI)



Synchrotron and neutron research in Russia



In accordance with the decree, the “Kurchatov Institute” is the leading scientific organization for the implementation of the Synchrotron and Neutron Research Development Program



УКАЗ

ПРЕЗИДЕНТА РОССИЙСКОЙ ФЕДЕРАЦИИ

О мерах по развитию синхротронных и нейтронных исследований и исследовательской инфраструктуры в Российской Федерации

В целях комплексного решения задач ускоренного развития синхротронных и нейтронных исследований, необходимых для создания прорывных технологий, а также обеспечения создания и развития исследовательской инфраструктуры в Российской Федерации постановляю:

1. Правительству Российской Федерации:

а) в 3-месячный срок разработать и утвердить Федеральную научно-техническую программу развития синхротронных и нейтронных исследований и исследовательской инфраструктуры на 2019 - 2027 годы (далее - Программа);

б) обеспечить при разработке и реализации Программы:

определение основных направлений исследований, касающихся решения принципиально новых фундаментальных и крупных прикладных задач в целях реализации приоритетных направлений научно-технологического развития и достижения национальных

УТВЕРЖДЕНА
постановлением Правительства
Российской Федерации
от 16 марта 2020 г. № 287

ФЕДЕРАЛЬНАЯ НАУЧНО-ТЕХНИЧЕСКАЯ ПРОГРАММА

развития синхротронных и нейтронных исследований
и исследовательской инфраструктуры на 2019 - 2027 годы

ПАСПОРТ

Федеральной научно-технической программы
развития синхротронных и нейтронных исследований
и исследовательской инфраструктуры на 2019 - 2027 годы

Наименование Программы	- Федеральная научно-техническая программа развития синхротронных и нейтронных исследований и исследовательской инфраструктуры на 2019 - 2027 годы
Основание для разработки Программы	- Указ Президента Российской Федерации от 25 июля 2019 г. № 356 "О мерах по развитию синхротронных и нейтронных исследований и исследовательской инфраструктуры в Российской Федерации"

Decree on the development of synchrotron-neutron research (25.07.2019)

Federal program for the development of synchrotron and neutron research until 2027 (16.03.2020)

Visit of Vladimir Putin to the NRC “Kurchatov Institute” (10.04.2018)





The program should provide



- ✓ **Formation of a united community of users of synchrotron and neutron radiation sources** covering scientific organizations, universities, applied science and industrial companies;
- ✓ **Complementarity of the formulation and solution of global scientific problems** in the framework of synchrotron and neutron studies, the distribution of scientific problems considering the scientific, technical and technological needs of the regions;
- ✓ **Territorial coherence of the country** by creating a branched research infrastructure of synchrotron and neutron research in the framework of solving the scientific problems;
- ✓ **International cooperation** by attracting foreign research organizations to participate in Russian projects and the integration of domestic research network infrastructure in the activities of the global scientific community.

Scientific directions of the Program

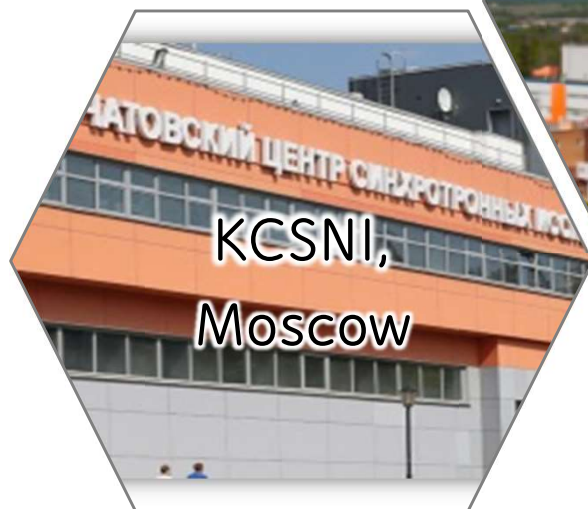


1. Synchrotron and neutron researches for material sciences and industry technologies.
2. Synchrotron and neutron researches for life sciences, organic and hybrid materials.
3. Synchrotron and neutron researches for socio-humanitarian sciences, including research on historical materials and cultural heritage.
4. Development of accelerator and reactor technologies, including technologies of nuclear medicine.



The objectives of the Program

Creation and development of
scientific and technological
infrastructure





Scientific infrastructure of the breakthrough



BASIC SYNCHROTRONS "Workhorses" – 1,5-3 GeV (>70)



Kurchatov synchrotron 2,5 GeV

Far Eastern
synchrotron 2,5 GeV



SKIF, 3 GeV



PIK



USSR-4, 6 GeV



BREAKTHROUGH

FLAGMAN SYNCHROTRONS 6 - 8 GeV (~1000 m)

APS - USA

Spring-8 - Japan

Petra III - Germany

ESRF-EBS - France

USSR-4, RUSSIA

Support and development
of existing technologies

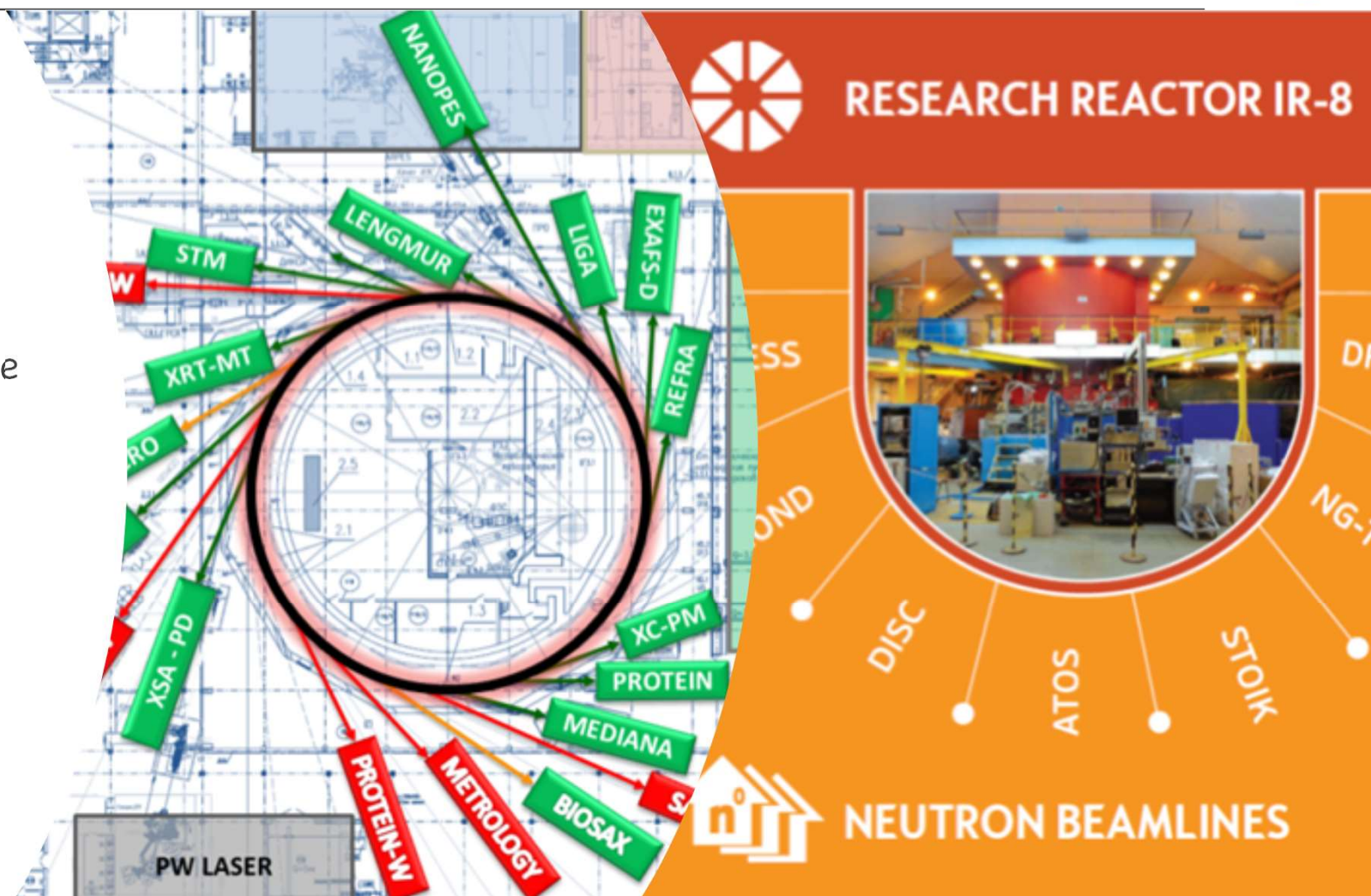
General information about KCSNI



KCSNI is one of the few places in the world where synchrotron (KSRS) and research reactor (IR-8) are located on the same site

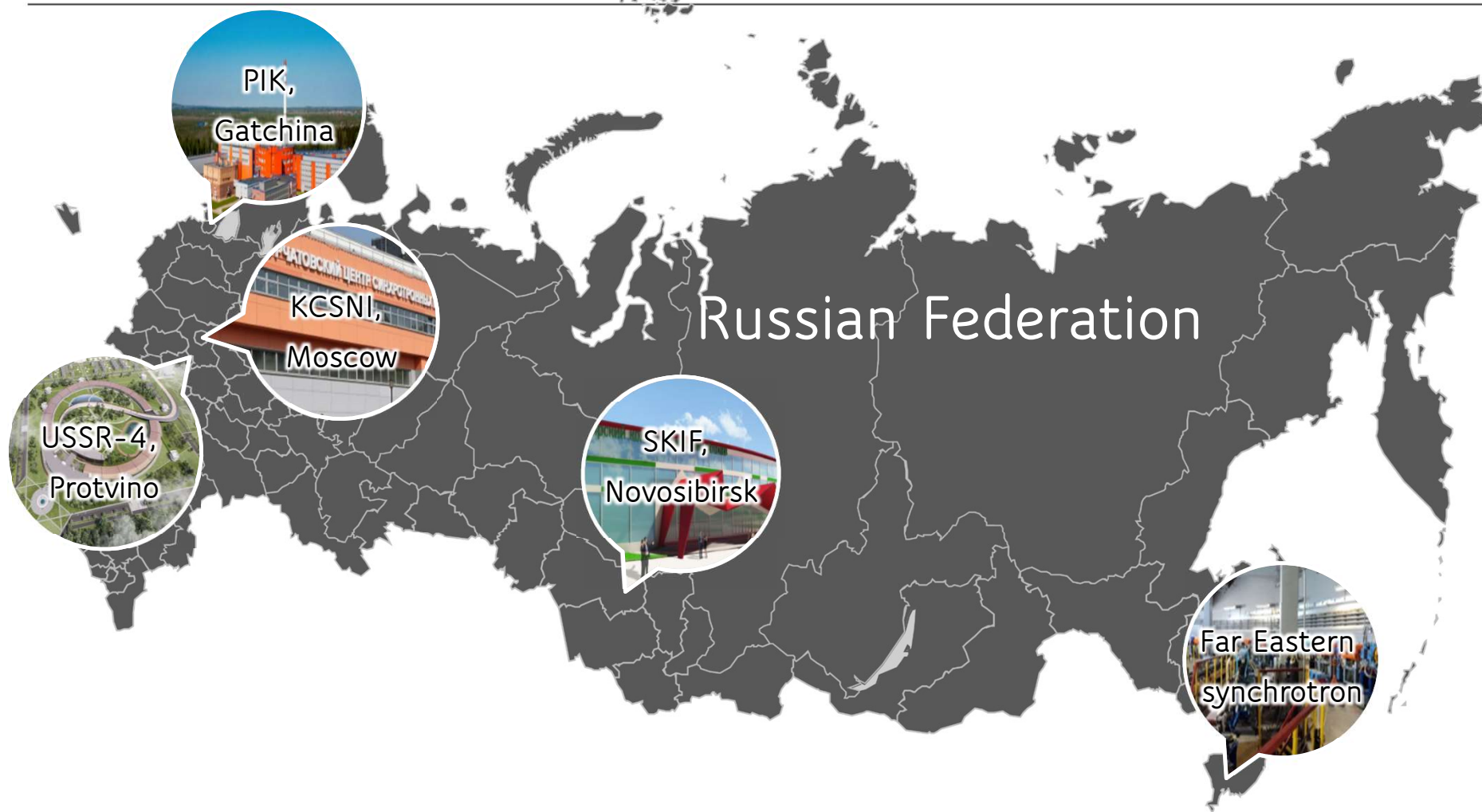
KSRS: 16 beamlines
(5 under construction)

IR-8: 7 beamlines
(3 in construction)



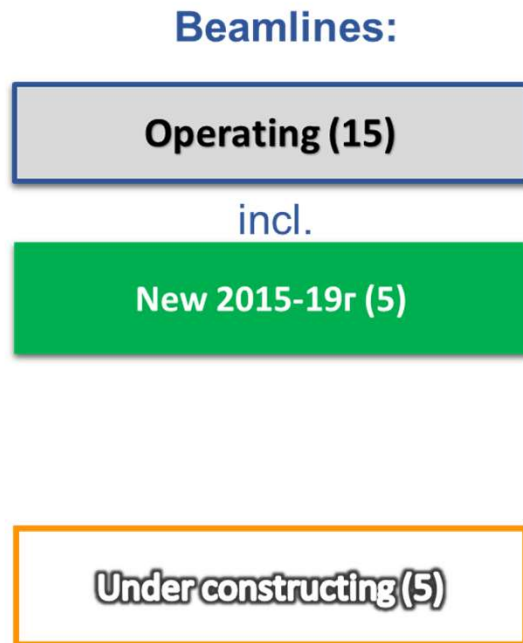


Location of the facility

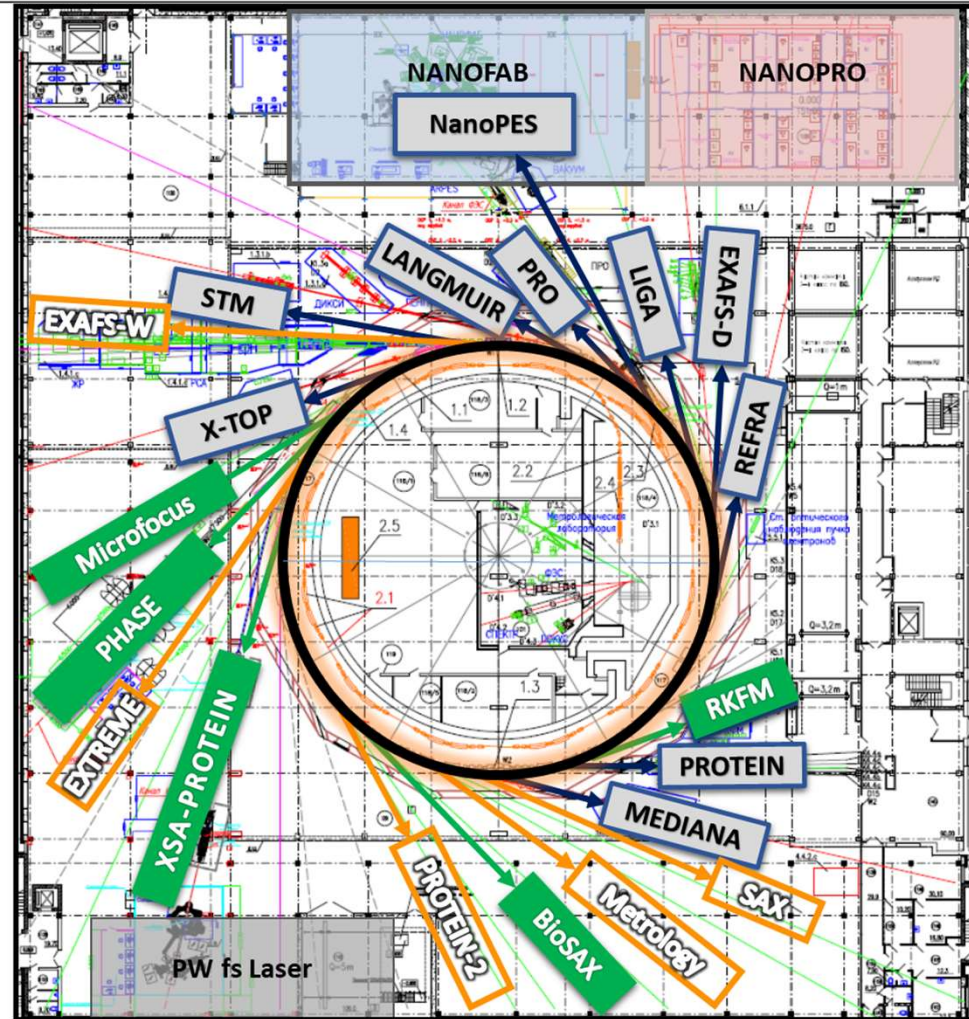




Kurchatov synchrotron radiation source



100 m





KSRS - beamlines



- ✓ **LANGMUIR** - X-ray studies of molecular films on liquid surfaces
- ✓ **BIOSAX** - small-angle X-ray scattering for biosystems
- ✓ **RSA (XRD)** - atomic and real structures using single- and polycrystalline diffraction
- ✓ **PHASE** - precision X-ray diffractometry and reflectometry, phase-sensitive methods for studying substances.
- ✓ **BELOK (PROTEIN)** - X-ray diffractometry of macromolecular single crystals
- ✓ **RKFM** - materials structure characterization by X-ray diffraction and scattering methods
- ✓ **PRO** - X-ray diffraction methods for the study of matter
- ✓ **STM** - studying the features of the spatial structure of materials in a wide scales range by spectroscopy
- ✓ **REFRA** - EXAFS spectroscopy in the fluorescence mode and X-ray fluorescence elemental analysis
- ✓ **EXAFS-D** - polycrystalline and amorphous materials study by X-ray spectroscopy and diffraction
- ✓ **NANOPES** - electronic structure of solids by photoelectron, optical and probe spectroscopy
- ✓ **RT-MT** - topography and microtomography
- ✓ **MEDIANA** - synchrotron visualization for medical and materials science diagnostics
- ✓ **LIGA** - three-dimensional visualization of large objects (1 - 10 cm) using the X-ray computed tomography



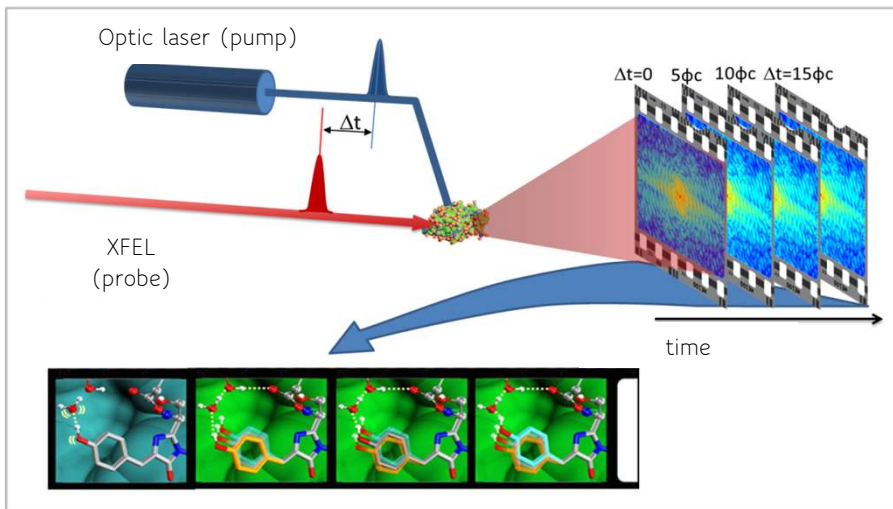
KSRS: new beamlines



KSRS: laser-synchrotron complex



Synchronization of short synchrotron pulses from KSRS with **femtosecond petawatt optical pulses** from laser complex is expected to give a possibility for pump-probe time-resolved experiments



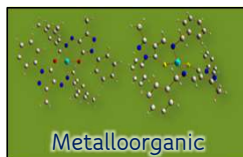
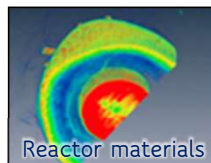


KRSR: scientific areas



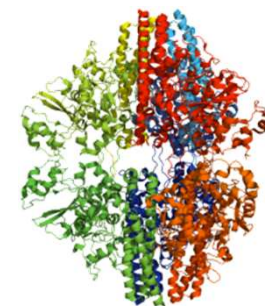
Crystallography, material science, structural chemistry

- STM
- DIKSY
- XSA
- X-TOP



Protein crystallography, molecular biology, medicine

- PROTEIN
- DIKSY
- Langmuir
- Mediana



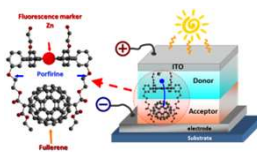
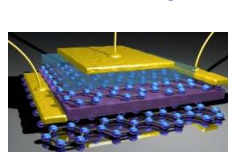
Micro- and Nanoelectronics, hybrid materials

PHASE

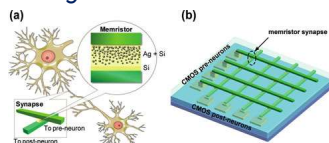
RKFM

NanoPES

Langmuir

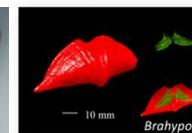


Organic and hybrid multilayer systems



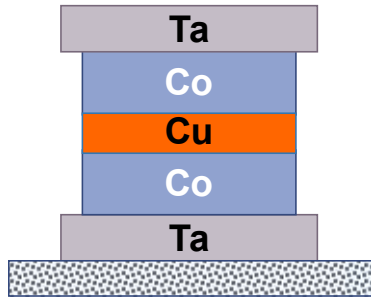
Cultural heritage

- REFRA
- STM
- DIKSY
- RKFM
- Mediana





KSRS: material science results



Magnetic structure on
the effect of giant
magnetoresistance

The task of research:

How does the
nonmagnetic Cu layer
behave?

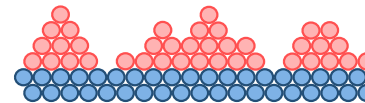
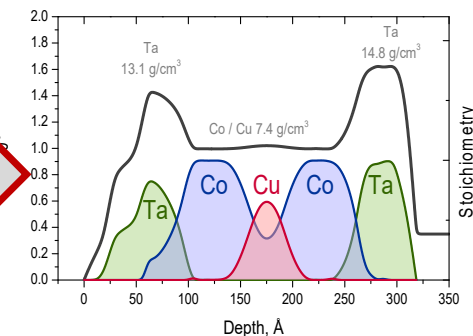
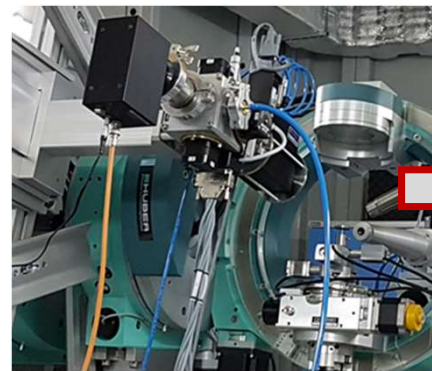
How are the Co layers
separated?

27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546
8.9 g/cm ³	8.92 g/cm ³	



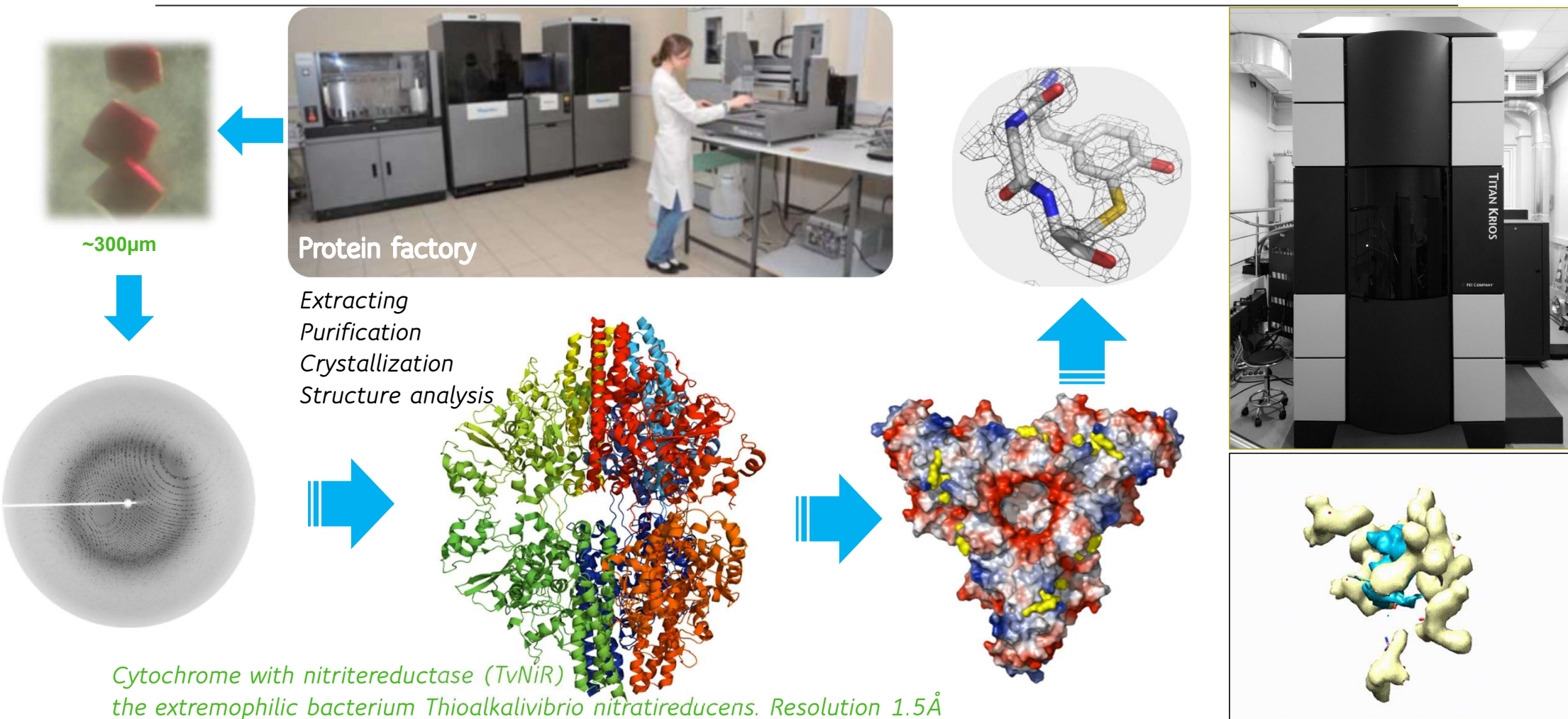
Standard methods
(reflectivity) are not
sensitive to the structure
of the layers of Co and Cu!

Standing x-ray waves method



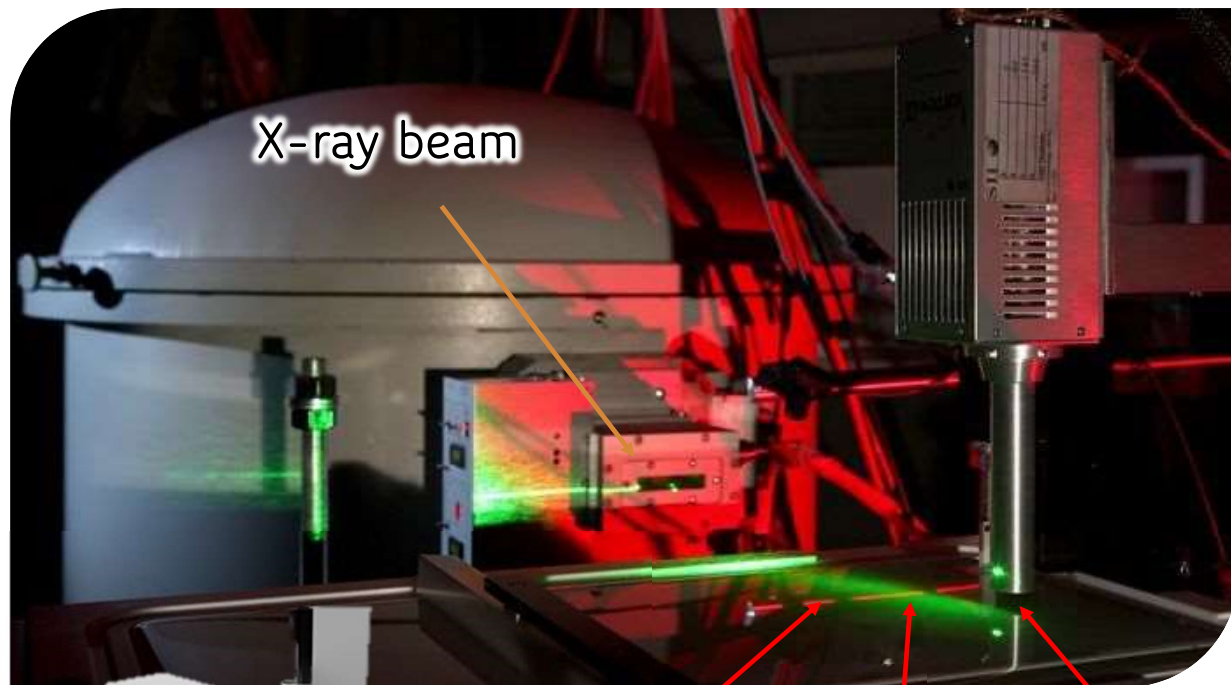
RESULT: The island mechanism of Cu growth,
the formation of an alloy of CuCo

KSRS: biology and life science results





KSRS: life science results

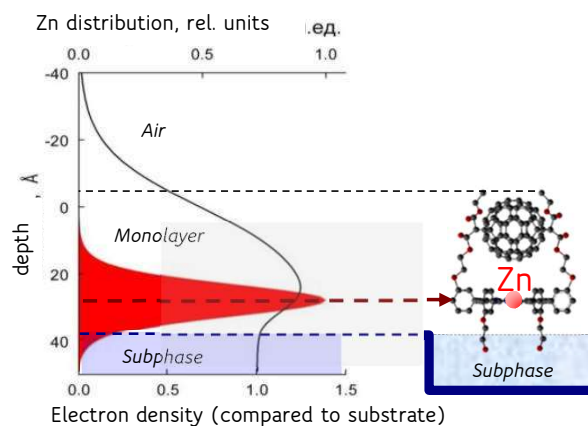
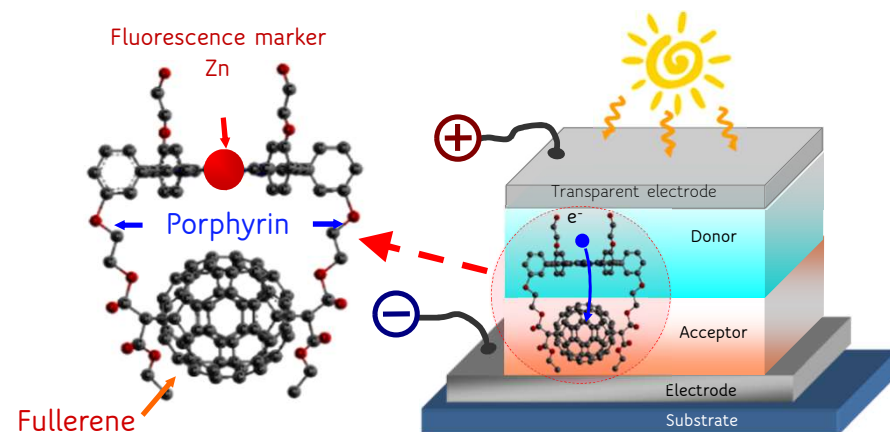


Langmuir bath

Fluorescence detector

Bioorganic monolayer on liquid surface

Determination of the orientation of the fullerene-porphyrin dyad on the surface of the subphase

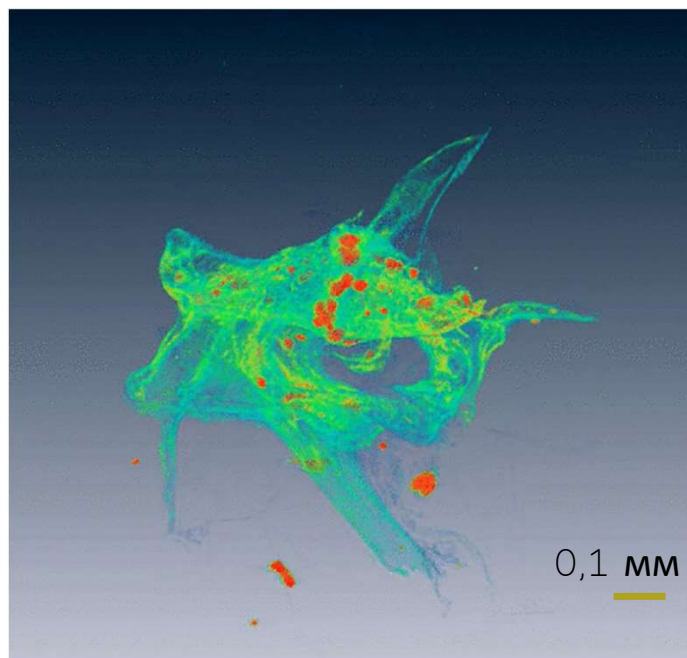




KSRS: life science results

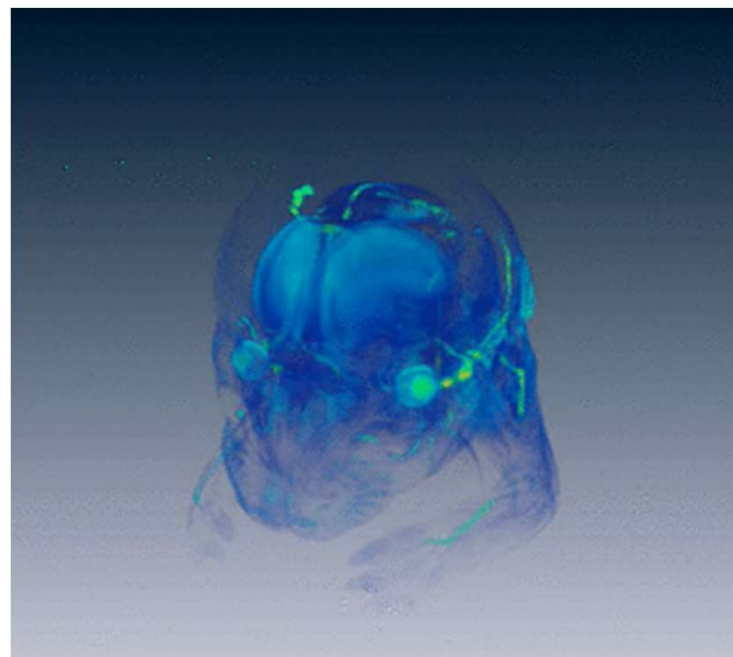


Decalcification studies of bones in
a long stay in space



Gecko vertebra after space flight

Learning cognitive processes
using x-ray tomography



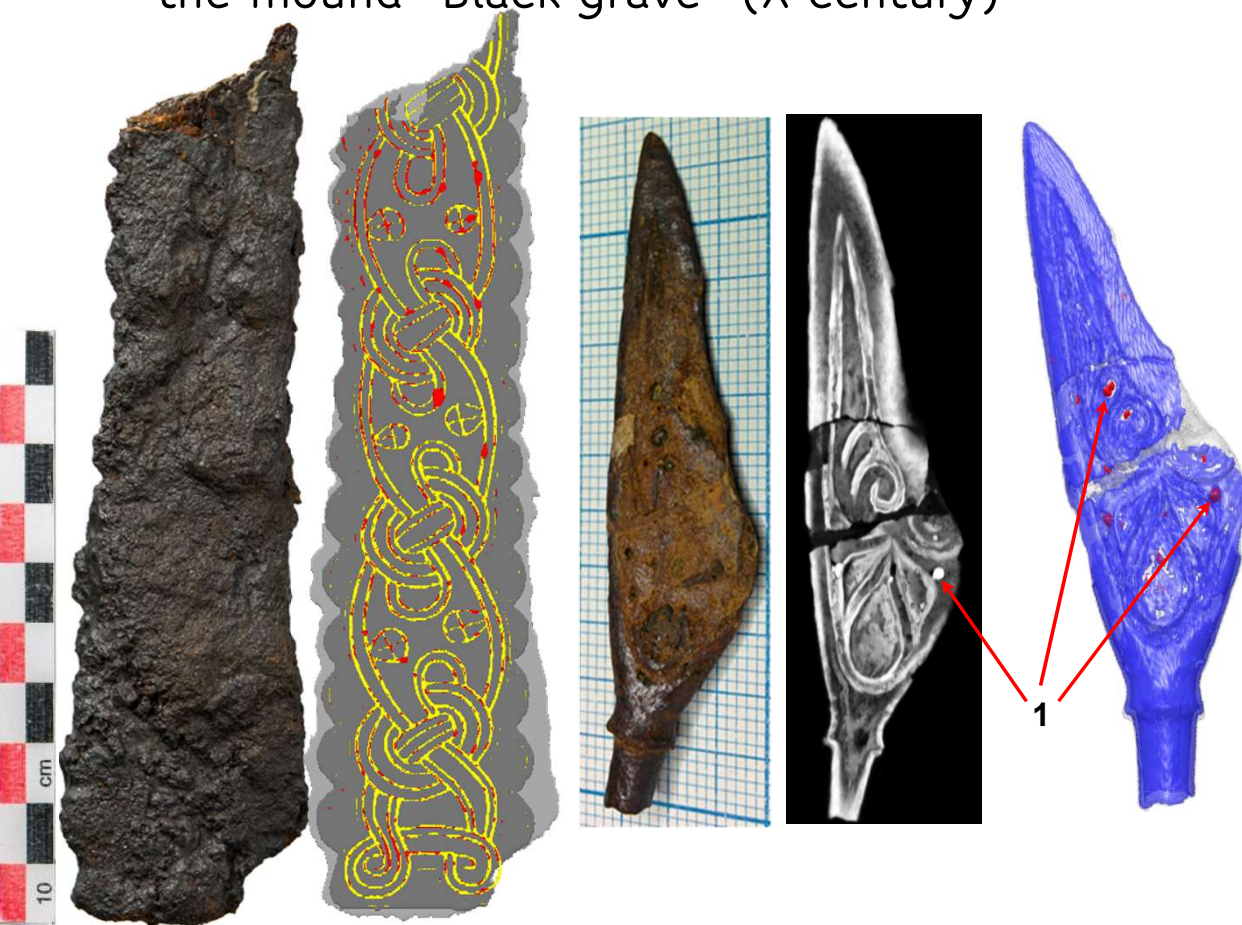
Active centers in the brain of a
newborn mouse visualization



KRSR: cultural heritage results

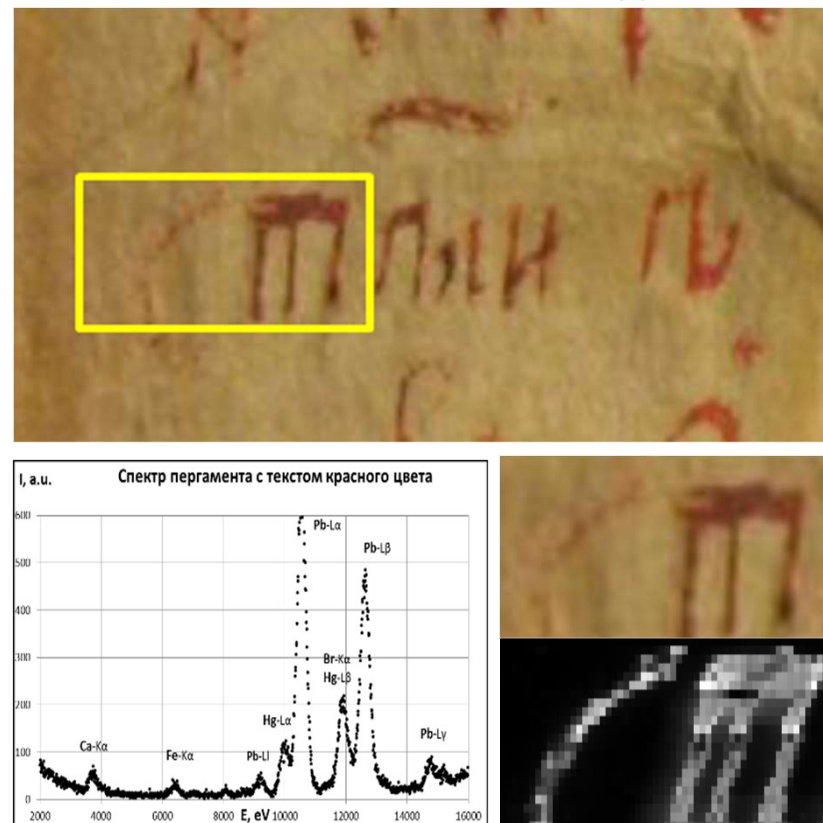


Objects with an ornament from the mound "Black grave" (X century)



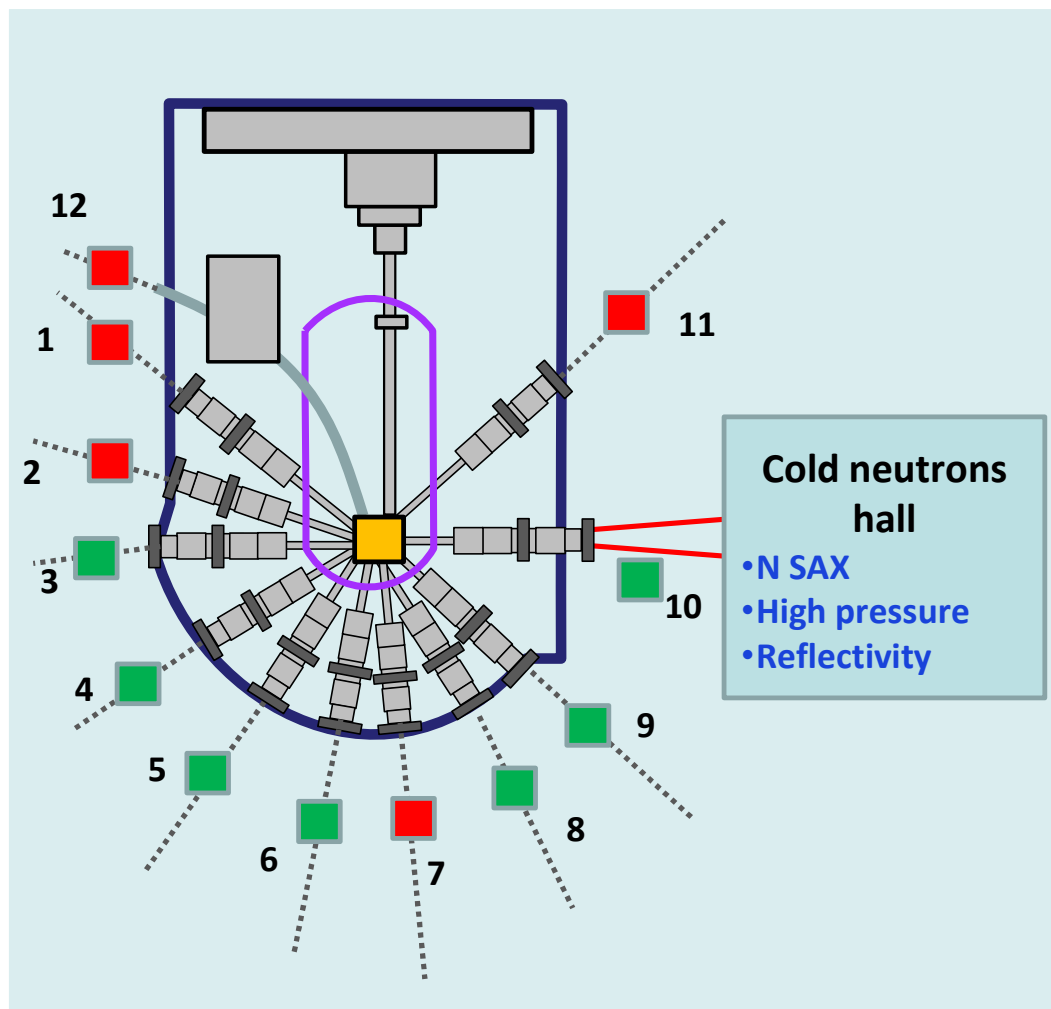
Slavic medieval parchments

X-Ray fluorescence 2D mapping





Neutron reactor IR-8



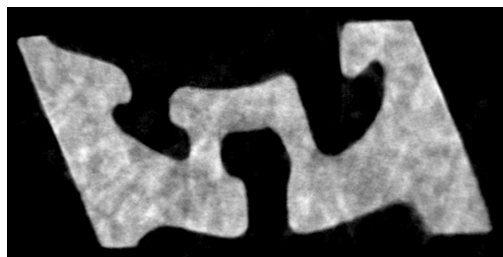
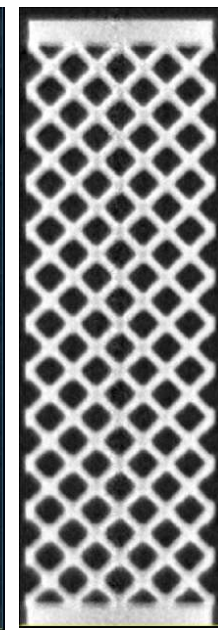
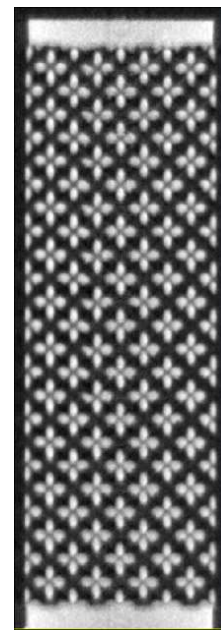
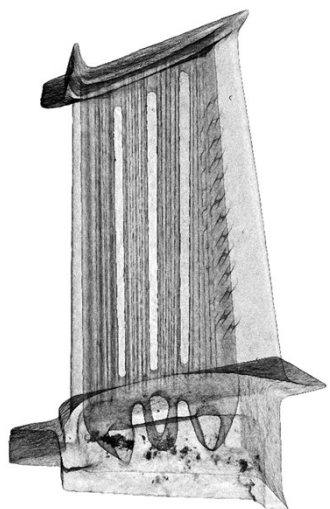
■ Nuclear-physics channels

■ Experimental channels

- 1 - Ultra cold neutrons
- 2 - Nuclear spectroscopy
- 3 - Stress analysis
- 4 - Single crystals
- 5 - Inelastic scattering
- 6 - High pressure
- 7 - Capillary optics
- 8 - n , γ -radiography
- 9 - Small angular scattering
- 10 - Cold neutrons source

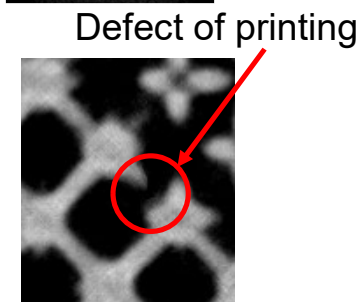
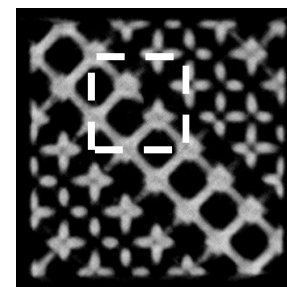


IR-8: material science results



Neutron visualization of the blade of gas turbine engine

Tomographic projections of products with a mesh structure obtained by the additive technology



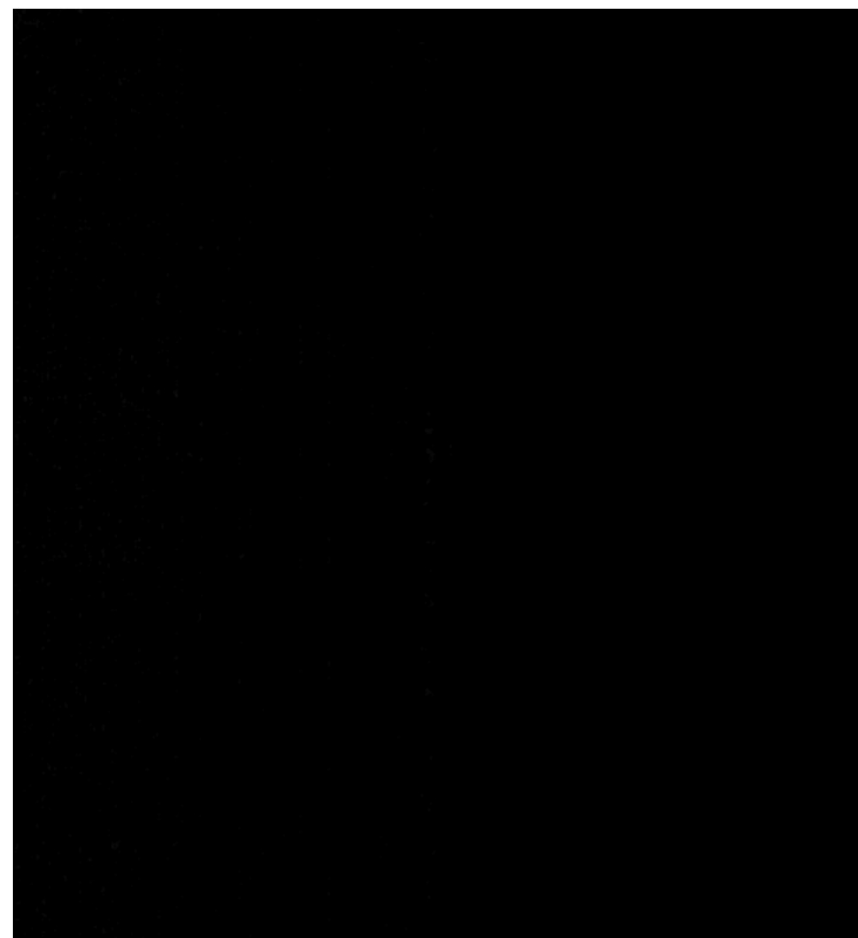
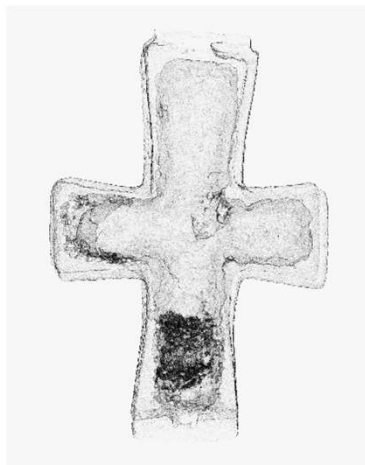
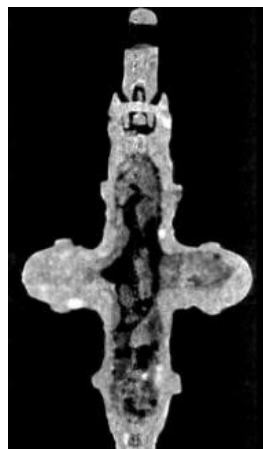


IR-8: cultural heritage results



X-Rays

Neutrons





NBICS infrastructure



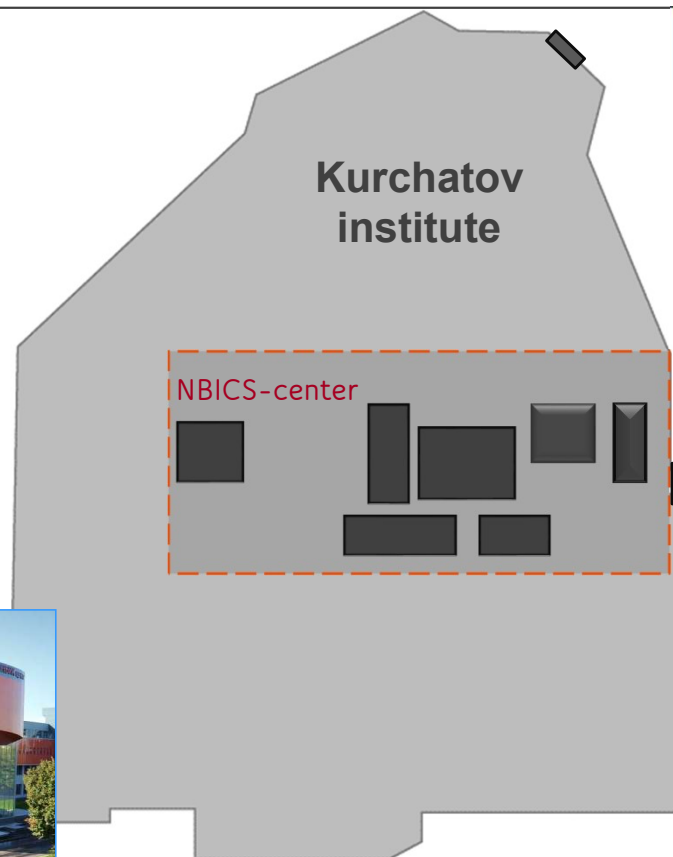
Neutron reactor IR-8



Cognitive science labs



Technological labs



Kurchatov
institute

NBICS-center



Synchrotron source



Nano-bio-labs



Supercomputer and data center

Large-scale facilities of KSRS surrounded by scientific laboratories of NBICS center makes Kurchatov institute a really **unique place** in the whole world **for fundamental and applied interdisciplinary researches**



Scientific technological platforms of NBICS

- ✓ Hybrid systems, integration of nanobiotechnologies and microelectronics **HYBRID**
- ✓ Synthesis of neurophysiology, cognitive and social sciences **BRAIN**
- ✓ Brain-machine interfaces, hybrid sensor systems **BIONIC ROBOTICS**
- ✓ Genomic medical technologies of personal medicine and ethnogenetics **GENOM**
- ✓ Drug design, regenerative medicine **BIOMEDICINE**
- ✓ Nuclear medicine and radiopharmaceuticals **IZOTOP**
- ✓ The effect of radiation on living systems **BIORADIATION**
- ✓ Promising energy technologies: generation and consumption, bioenergy **ENERGOTECH**
- ✓ Multi-level computer modeling and design **SUPERCOMP**
- ✓ Interdisciplinary **EDUCATION**



KCSNI: statistics



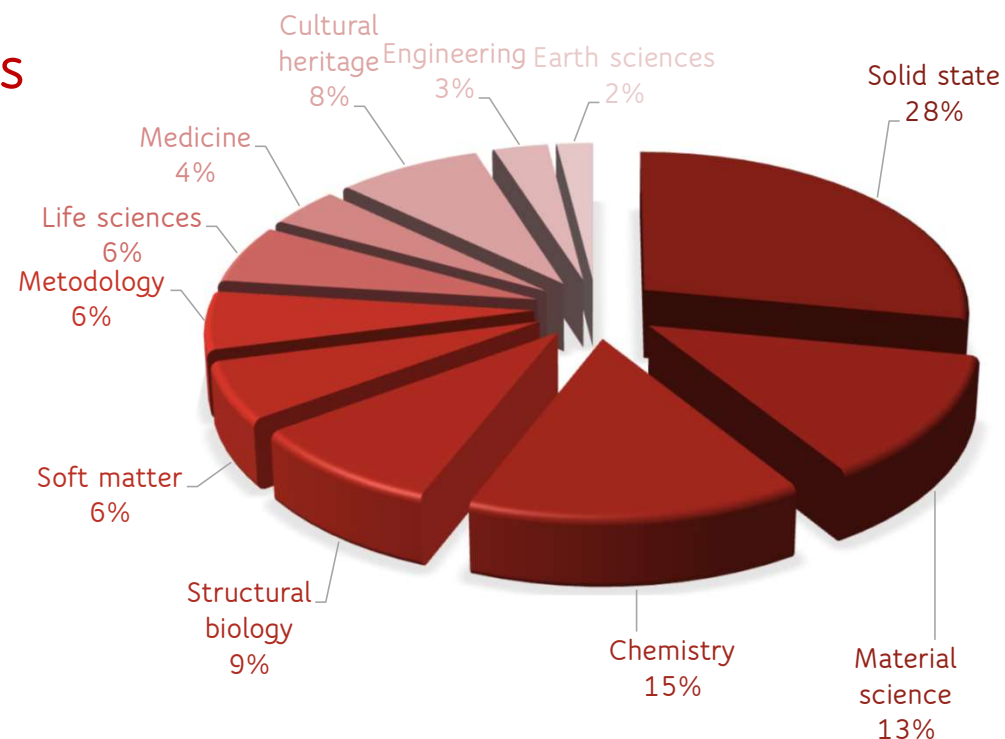
more than 200 experiments annually

60 Russian and foreign **user organizations**

more than 150 research **papers** annually

User affiliation (sorted by beamtime):

- 47% - scientific organizations,
- 26% - universities,
- 23% - internal Kurchatov institute users,
- 2% - industry users
- 2% - foreign users





KCSNI: users

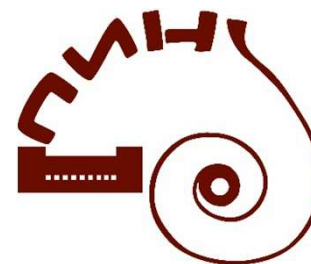


Top 10 users (by allocated time)

1. NRC "Kurchatov institute"
2. Lomonosov Moscow State University
3. Borissiak Paleontological Institute RAS
4. Federal Research Center "Crystallography and Photonics" RAS
5. Kazan Federal University
6. Kurnakov institute of general and inorganic chemistry RAS
7. Frumkin Institute of Physical chemistry and Electrochemistry RAS
8. Boreskov Institute of Catalysis SB RAS
9. Voronezh State University
10. Institute of Nuclear Physics SB RAS



LOMONOSOV MOSCOW
STATE UNIVERSITY





International partners



ESRF - European Synchrotron Radiation Facility



DESY - Deutsches Elektronen-Synchrotron



HZB - Helmholtz Centrum Berlin



ELETTRA - Italian synchrotron



Armenian academy of sciences



Azerbaijan Academy of sciences



Access policy



- ✓ Single procedure for all types of users (via official website)
- ✓ Proposal review procedure **every month**
- ✓ The key principle of the access – **research made by our staff with active participation of the proposers** (direct and remote access)
- ✓ Easy access for Russian citizens
- ✓ **For foreign citizens** visits to our institution is controlled by federal agencies, and an application for a pass must be submitted **40 days in advance**.
- ✓ Assistance in obtaining a Russian visa



KCSNI: website



NATIONAL RESEARCH CENTER
"KURCHATOV INSTITUTE"

ru / en

KURCHATOV COMPLEX FOR SYNCHROTRON AND NEUTRON INVESTIGATIONS

About Kurchatov Complex for Synchrotron and Neutron Investigations

History

Synchrotron radiation source

Beamlines of the Kurchatov specialized source of synchrotron radiation "KISI-Kurchatov"

Neutron research complex based on the IR-8 research reactor

Beamlines at IR-8 neutron research reactor

Publications 2018

Contacts

APPLY FOR BEAMTIME

Nowadays, fundamental scientific research and revolutionary high-tech developments around the world concentrates in research centers formed around unique mega-science research facilities - synchrotron radiation and neutron sources. In these facilities scientists can perform high-level research by using a variety of complementary methods that provide them with the most complete overview of physical, chemical and biological phenomena and effects under study. In these centers they can also develop unique technological processes for manufacturing of functional systems and their components in the conditions of experimental and further industrial production. Kurchatov Complex for Synchrotron and Neutron Investigations is among few places in the world that gathers at the same site research reactor, synchrotron radiation facility, laboratory with advanced X-ray instrumentation and mega-class supercomputer for modeling and data processing. This unique combination of capabilities helps to achieve a brand new quality of fundamental and applied research.

Today, the "KISI-Kurchatov" research infrastructure consists of 10 beamlines of various research directions, from physics, chemistry, biology research to applied developments in materials science, medicine, archaeology and cultural heritage. Beamlines are equipped with sophisticated state-of-art X-ray optical facilities, vacuum chambers, detectors and up-to-date control systems. A substantial modernization of the existing beamlines is underway, as well as commissioning of 5 new beamlines. More than 200 experiments are provided annually by "KISI-Kurchatov" for the research groups from approximately 60 Russian and foreign organizations, in numerous research fields including structural diagnostics of nanotechnology and microelectronics materials; studies of atomic structure of organic and biological objects for genetic engineering, biotechnology and design of new drugs; studies of cultural heritage and archaeological samples, etc. Each year Kurchatov Synchrotron is involved in more than 150 research papers.

A complex of laboratory X-ray instrumentation is designed to perform express analysis of atomic and molecular structure of user samples. It complements capabilities of the synchrotron beamlines, provides an option to perform preliminary study of user samples and to trial experimental techniques before their implementation at megascience facilities.

The neutron research complex is based on the IR-8 nuclear reactor commissioned in 1981. It is designed for scientific research in various fields of physics, chemistry and medicine using neutrons in a wide range of wavelengths and various research techniques. The complex is equipped with 6 experimental stations. The research reactor IR-8 is included in the federal register of unique scientific facilities, as well as synchrotron radiation facility "KISI-Kurchatov".

Today, the megascience facilities of Kurchatov Complex for Synchrotron and Neutron Investigations are the methodological basis for the development of the new scientific field related to the convergence of nano-, bio-, information, cognitive and socio-humanitarian (NBICs) sciences within the walls of NRC "Kurchatov Institute" and the formation of fundamentally new nature-like technologies.



NATIONAL RESEARCH CENTER
"KURCHATOV INSTITUTE"

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KURCHATOV COMPLEX FOR SYNCHROTRON AND NEUTRON INVESTIGATIONS

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History

Synchrotron radiation source

Beamlines of the Kurchatov specialized source of synchrotron radiation "KISI-Kurchatov"

LANGMUIR
BIOSAX
RSA (XRD)
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RKFM
PRO
STM
REFRA
EXAFS-D
NANOPES
RT-MT
MEDIANA
LIGA

Neutron research complex based on the IR-8 research reactor

Beamlines at IR-8 neutron research reactor

Publications 2018

Beamlines of the Kurchatov specialized source of synchrotron radiation "KISI-Kurchatov"

PHASE



Specialized beamline for diagnostics using methods of precision X-ray diffractometry and reflectometry, as well as phase-sensitive methods for studying substances.

Methods:

- X-ray Standing waves (XSW);
- High-resolution diffraction (XRD);
- Multiwave diffraction;
- Surface diffraction;
- X-ray acoustooptics;
- X-ray holography;
- Resonance diffraction;
- X-ray Reflectometry (XRR);
- Diffuse scattering.



KCSNI: contacts



Web site: <http://kcsni.nrcki.ru/en.shtml>

Facility Head:
Nikita Marchenkov

Deputy for the users:
Roman Senin: senin_ra@nrcki.ru
+7 916 594 39 33





Thank you for attention!



kcsni.nrcki.ru



synchrotron@nrcki.ru