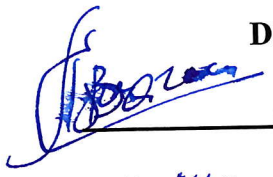
Annex 4.

Project report form

APPROVED

Director of Laboratory



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"04" мая 2026

REPORT ON PROJECT (INFRUSTRUCTURE PROJECT)
IN FIELD OF RESEARCH WITHIN
THE TOPICAL PLAN FOR JINR RESEARCH

1. General information on the Project
1.1. Scientific field: Nuclear Physics (03);

1.2. Name of the Project: Modernization of the EG-5 accelerator and its experimental infrastructure;

1.3. Project code: 03-4-1146-2-2022/2026;

1.4. Theme code: 03-4-1146-2024 "Neutron Nuclear Physics";

1.5. Actual duration of the Project: 2024-2026

1.6. Project Leader(s): Doroshkevich A.S.

2. Technical report

2.1. Annotation

The EG-5 accelerator is an efficient and versatile nuclear physics instrument used to address a wide range of current scientific problems in nuclear physics, specifically the acquisition of nuclear data for nuclear and fusion power engineering, as well as astrophysics [Nuclear Data High Priority Request List: https://www.oecd-nea.org/dbdata/hprl/search.pl?vhp=on]. The EG-5 electrostatic accelerator is part of the modern fleet of JINR's basic facilities—ionizing radiation sources in the energy range up to 15 MeV.

The goal of the project was to provide the technical capability for the implementation of the JINR Topical Plan (PTP) regarding the study of reactions with fast quasi-monoenergetic neutrons, the development of nuclear-physical methods for elemental composition research, solving problems in neutron radiation materials science, implementing practical applications of neutron physics, and ensuring the technical capability for unique microbeam spectrometer options.

Project Tasks. The primary technical task (Task 1) of the project was to restore the accelerated particle energy range to 900 keV – 4.1 MeV and increase the ion beam current to 100 μA, while maintaining ion beam energy stability no worse than 500 eV and ensuring spatial beam stability sufficient for the implementation of a microbeam spectrometer / nuclear microprobe.

The project tasks also included **updating the experimental infrastructure of the accelerator complex (Task2)**, specifically the development of new methods for studying the physical properties of material surfaces to complement and enhance the quality of the scientific output, and the establishment of a specialized laboratory for sample preparation and testing.

The main organizational task was the establishment and development of human resource potential to ensure the full execution of the project and the conduct of scientific research at the accelerator for a perspective of at least three 7-year periods **(Task 3)**, the preparation of a documentation package and the implementation of measures necessary to obtain permits for the resumption of ESA (Electrostatic Accelerator) operation, and the intensification of international scientific and technical cooperation.

The primary criteria for successful project completion were stated as: obtaining a neutron flux sufficient for nuclear physics experiments with fast neutrons (1) and ensuring beam luminosity and energy stability sufficient to create a microbeam spectrometer/nuclear microprobe (2).

Declared results upon project completion: Restoration of the accelerator's technical parameters (accelerated particle energy of 4.1 MeV at a maximum current of at least 100 μA) and ensuring the technical conditions for conducting research on fast neutron reactions at JINR, as well as providing the technical conditions for the installation of a microbeam spectrometer (1). A neutron generator based on a solid lithium target with a moderator should be added to the existing gas-target neutron generator (2), and the ion beam irradiation chamber should be modified (3).

Installation of a new specialized laboratory for sample preparation, equipped with complementary methods for studying optical and electronic surface properties, such as ellipsometry, optical and electron microscopy, and techniques for studying DC and AC electrical properties (voltammetry, impedance spectroscopy).

Securing human resource potential for the next 20–30 years.

- New elemental analysis methods (PIGE) and neutron activation analysis (NAA).
- Ensuring the possibility of conducting a series of new, unique experiments in the near term to measure energy spectra and angular distributions of charged particles from(n,α) and (n,p) / (α,n)and (p,n) reactions, as well as integral and differential cross-sections in the neutron energy range up to ~6 MeV, nuclear fission processes by fast neutrons, activation analysis, and neutron materials science experiments.

Declared annual results according to the JINR PTP with status of completion:

2024

1. Certification and commissioning of the EG-5 accelerator and its experimental halls in test mode – **Completed** (at the moment of the end of the project);
2. Replacement of the high-voltage accelerator tube and ion source that have lost their performance characteristics – **Not completed**;
3. Achievement of an ion beam current exceeding 100 μA – **Partially completed**;

4. Improvement and adjustment of the EG-5 ion optics parameters (reconfiguration from focuser to condenser mode) – **Not completed**;
5. Modernization and automation of the gas-handling system, adaptation of the process flow – **Partially completed**;
6. Modernization of the vacuum system – **Completed**;
7. Automation of all accelerator service systems – **Partially completed**;
8. Launch of the laboratory for engineering and sample research using methods complementary to ion-beam techniques – **Partially completed**;
9. Formation of the group's human resource potential – **Partially completed**;
10. Implementation of technical projects, specifically the project with JSC "Mikron" ("Preparatory work including the fabrication of an ion beam scanning system, as well as test electron-beam processing and testing using impedance spectroscopy of semiconductor wafers up to 150 mm in diameter"), the technical project with "ROSATOM" State Corporation ("Study of the energy dependence of the UDKN-04R device sensitivity"), and projects with JSC "Angstrem" and others – **Completed**.

2025

1. Certification and commissioning of the EG-5 accelerator and its experimental halls – **Completed** (at the time of the PAC meeting).
2. Replacement of the selsyn-based control system with an optoelectronic analog – **Not completed**.
3. Modernization of the radiation control and personnel protection system – **Completed** (at the time of the PAC meeting).
4. Modernization of the ion-beam spectrometer complex – **Partially completed**.
5. Commissioning of the solid-state lithium neutron-producing target – **Completed**.
6. Automation of accelerator service systems – **Not completed**.

2026

1. Physical experiments using the old ion source and accelerator tube – **Completed**.
2. Development of a control system for the new ion source – **Partially completed**.
3. Development of the accelerator automation and control project – **Not completed**.
4. Delivery of the new accelerator tube and its installation along with the new ion source – **Not completed**.

Modernization Measures Conducted for the EG-5 ESA (Summary). Within the reporting phase of the deep modernization project "Modernization of the EG-5 Accelerator and its Experimental Infrastructure" (2024–2026), core technical systems were updated with support from the Budker Institute of Nuclear Physics (Novosibirsk). Specifically, a deep modernization of the vacuum system was carried out: oil pumps were eliminated, terminal pumping stations based on turbomolecular pumps were installed, preventive system cleaning was performed, and vacuum connections were unified to modern standards. A lithium-target neutron source (20 keV – 800 keV) was launched, the ion beam irradiation chamber was modified, and the methodological base of the accelerator complex was expanded.

In accordance with the assigned nuclear-physics tasks, the facility's floor plan was rezoned, radiation control and interlock systems were installed and commissioned, carousel-type doors to the ESA halls were repaired, and several preparatory tasks were completed to obtain the Sanitary-Epidemiological Conclusion (SEC) for the accelerator and experimental halls. The gas-handling system was modernized, including the replacement of the high-pressure compressor and pressure regulators, which had been the subject of the ROSTEKHNADZOR injunction and the order prohibiting EG-5 operation since 2014. Design calculations were performed and structural elements for the new ESA accelerator tube were manufactured; a modern microwave ion source (MWIS) was built and delivered to JINR.

As a result of the modernization of the basic EG-5 configuration, the ion beam current was increased to the nominal design value (from 1.5 to 30 μA) and the accelerated particle energy reached 85% of the nominal value (from 2.8 to 3.5 MeV), corresponding to 60% and 85% of the values declared in the JINR Seven-Year Development Plan for 2024–2030.

Through organizational and technical efforts, it was possible to resume the operation of the EG-5 in its basic configuration in test mode (without the gas compressor station).

In addition to the modernization of the ESA's core components, a new specialized laboratory for sample preparation was installed. It is equipped with complementary methods for studying optical and electronic surface properties, such as ellipsometry, optical and electron microscopy, and DC/AC electrical characterization (voltammetry, impedance spectroscopy). Within the DNP FLNP, the Sector of Nuclear

Physics Materials Science and Ion-Implantation Nanotechnologies was formed, comprising a team of technical specialists (Nuclear Physics Experiment Technical Support Group) and scientists specializing in ion-beam research methods and related scientific topics. The sector produces over 20 scientific publications annually, one-third of which are in top-tier Q1 and Q2 journals.

The project was fully funded.

Unresolved tasks include the absence of the compressor replacement project (currently in progress by "Promexpertiza" LLC (1)), the control system for the new ion source requires finalization (the contract with BINP is signed (2)), the accelerator tube requires bonding (the contract was canceled by BINP leadership (3)), the automation of most systems remains largely unimplemented (4), and the renovation of the accelerator hall and floor reinforcement in the Right Experimental Hall have not been completed (5). The task of automating the ESA service systems remains practically unsolved. Further equipping of the experimental halls and the specialized laboratory in Building 120 (DLNP site) with experimental hardware is required.

Factors limiting the completion of the project tasks and the primary reasons for deviations from the **Work Schedule** and ESA Resumption Plan (Appendices 5 and 6, respectively) include the failure of "Promexpertiza" LLC to meet documentation deadlines (1), the indefinite postponement of the AT bonding work by BINP leadership (2), the failure of FLNP JINR technical services to fulfill construction and repair requests (3), a shortage of internal qualified personnel within the technical group (4), and bureaucratic overhead (5).

Conclusion. To resolve the remaining tasks (replacement of the IS with a control system redesign (1), automation of the vacuum, gas-compressor, and beam control systems (2), preparation of missing technical documentation (3), replacement of the pressure vessel evacuation system (4), renovation of the EMA hall (5), installation of the electron microscope in the specialized laboratory in Building 120 (6), etc.) while simultaneously executing the scientific program, a project extension of at least one year is required. Furthermore, the technical group must be augmented with six additional specialists.

2.2. A detailed technical report

2.2.1. Description of the mode of operation and functioning of the main systems and equipment

Following the completion of work and technical measures within **Task 1** of the project (Improvement of technical parameters of the EG-5 accelerator), it was possible to increase the operating voltage at the EG-5 high-voltage terminal (in its basic configuration) from 2.5 to 3.5 MV (85% of the design value) and the ion beam current from 1.5 to 30 μA (100% of the design value and 60% of the value declared in the JINR Seven-Year Development Plan for 2024–2030, Table 1).

Table 1.

Baseline, design, and Seven-Year Plan operating characteristics of the EG-5 ESA

Parameter	Beforemodernization	Present State (2025)
Terminal voltage	2.5 MV	3.5 MV*
Beamcurrent	~ 1 μA	1 - 30 μA**

** 85% of the passport value*

** 100% of the passport value**

Within the framework of **Task 2** (Development of the experimental infrastructure of the accelerator complex), a solid-state Li-target, manufactured by colleagues from the Budker Institute of Nuclear Physics (Novosibirsk), was installed (Fig.4.1). The new target allowed for a significant expansion of the energy range of the produced neutrons. Consequently, the accelerator is currently suitable for operation in test mode and generates fluxes of quasi-monochromatic particles with the following characteristics:

CurrentIonbeamparameters:

- **Ionbeamcurrentrange:** 0.01 – 30 μA;
- **Ionbeamenergyrange:** 1.1 – 3.5 MeV;
- **Energy resolution (H^+, He^{2+}):** not worse than 500 eV;
- **Charged particles flux** (H^+, He_2^+): 10^{12}particles/(cm^2/s);
- **Neutron yield:** 5×10^7 n/s (gas target) and 10^9 n/s (Li target);
- **Neutron energy range**: 10 – 800 keV; 3.5 – 5.1 MeV ± 0.1 MeV;

22. Purchase and installation of uninterruptible power supplies (UPS) for the vacuum system pumps of channels No. 1–3;
23. Modernization of the RBS facility, including:
- replacement of the vacuum system with an oil-free one,
- addition of a turbomolecular pump to the system to reduce experiment preparation time (by 20 times),
- transition to digital vacuum system monitoring,
- installation of a video camera to monitor the ion beam shape for repeatable positioning on the sample,
- replacement of inlet flanges on the RBS chamber body.
24. Restoration of the support structure for the channel No. 2 beamline;
25. Replacement of quartz windows in the beam tuning and monitoring systems;
26. Development, manufacture, and installation of channel No. 3 for neutron experiments;
27. Addition of a modernized vacuum chamber to channel No. 3 for proton irradiation work;
28. Development and implementation of a rotating sample holder for irradiation;
29. Installation of a digital vacuum control system for channel No. 3.

Accelerator Hall:

1. Relocation of the Shimadzu turbomolecular pump (left) from the area designated for safe operation and maintenance of the SP-88 magnet;
2. Installation of water cooling supply and return for the pump;
3. Development and manufacture of flanges for pump connection;
4. Manufacture of racks for pump monitoring and control instruments;
5. Dismantling of shelves and cabinets obstructing pump installation;
6. Flushing of the SP-88 magnet cooling system;
7. Repair of the central hall rotating door;
8. Diagnostics of the rotating door opening mechanism to assess repair feasibility;
9. Implementation of manual (emergency) opening capability for the rotating door for the first time;
10. Replacement of the cables for the rotating door opening mechanism;
11. Calculation of the maximum torque of the reduction gear to assess the feasibility of replacing (upgrading) the motor;
12. Calculation and reinforcement of the general door opening mechanism structure;
13. Laying of telemetry lines (control and monitoring) for the new source in cable channels;
14. Calculation, manufacture, and installation of the telemetry system inlet under the accelerator "tank." Ensuring vacuum integrity and overpressure containment.

Building 120 (Room 115):

1. Preparatory work for room renovation;
2. Disassembly of metal structures and electrical equipment;
3. Dismantling of concrete blocks for motor placement;
4. Acquisition and delivery of the base for the laser cutting complex assembly (at the group's expense);
5. Assemblyofthebase;
6. Paintingofthebase;
7. Manufacture and installation of guides for the X and Y axes;
8. Replacement of linear bearings for the two-coordinate movement system;
9. Manufacture of the plate (base) for the new motor and Y-axis belt drive;
10. Development and manufacturing support for the drive and driven belt pulleys;
11. Development of the Z-axis cutting head mount;
12. Installation of cabinets for gas equipment outside Room 115;
13. Design of the assist gas supply system for metal cutting;
14. Purchase and installation of damping pads for the machine base;
15. Finalization of the finished parts delivery system from the cutting zone;
16. Assembly of the laser complex control workstation;
17. Calculation and assembly of the complex control circuits (in progress).

General Work on the EG-5 Accelerator:

1. Operational repairs of equipment that failed during operation, with restoration (where possible) or replacement of major units and assemblies with functional (not new) parts;
2. Completion of the full scheduled preventive maintenance cycle with short-term accelerator shutdowns;
3. Preventive maintenance of gas-handling equipment, the main pressure compressor, and vacuum equipment responsible for maintaining the operating environment in the accelerator tube and the protective pressure vessel.

2024

1. **Personnel Safety:** Ensuring radiation safety for personnel in the box of Building 42A (TANGRA) from the Experimental Hall No. 1 side; calculation and installation of a protective barrier (mandatory condition for obtaining the SES permit);
2. Development of a remote drive design for the beam transport device rotating mechanism (to ensure safety and minimize personnel time in the active zone);
3. Installation of a dosimetric monitoring and personnel protection system (condition for ESA commissioning);
4. Within the repair of the Accelerator Hall No. 1 rotating door, a complex of measures was carried out, including:
    - Replacement of the electric motor with a more powerful one;
    - Replacement of traction cables with a larger diameter;
    - Reinforcement of the door rotation drive structure;
    - Preventive maintenance of the reduction gear;
    - Repair of the external door protective shell;
    - Repair and maintenance of the carousel support bearing;
    - Repair of the electrical components of the rotation drive;
    - Repair of limit switches.

Result: The doors are fully operational (this was a major obstacle to commissioning; specialists had insisted on an expensive and unrealistic replacement with a modern analog and refused to participate in the repair).

5. **High-Voltage and Beam Transport System:** Restoration of the belt charge current stabilization unit; achieved current stability matching original design specifications;
6. Design of the vacuum storage system, purchase of the receiver, and commencement of vacuum fitting manufacture. Replacement of the fore-vacuum system with an oil-free one; ensured standard operation of turbomolecular pumps for evacuating the tube and the first segment of the beamline from the magnet;
7. Laying of a new signal line and installation of a digital vacuum display for the accelerator tube. Enabled rapid response to tube operating conditions and more accurate gas dosing into the ion source;
8. Finalization work on the "Dnepr" installation for silicon wafer irradiation:
    - Correction of wafer irradiation chamber assembly errors;
    - Modernization of the chamber, development and proposal of new technical solutions;
    - Implementation of a visual control system for beam scanning on the processed sample;
    - Refinement of the ion beam scanning system;

9. **IonBeamScanning System:**
    - Manufacture of magnetic coils with improved beam deflection parameters;
    - Calculation and tuning of the raster signal generator;
    - Replacement of low-voltage power supplies to improve field efficiency;
    - Design of a liquid cooling system for the scanning system coils;
    - Manufacture, installation, and debugging of the scanning system (power amplifiers, coils, cooling system, automated visual raster control);
    - Purchase and installation of a chiller for cooling.

These measures improved the quality of material processing for the customer, JSC "Mikron."

10. Calculation of the beamline design for operation with a solid-state neutron-producing target, along with the following associated work:
    - Support forbeamlinemanufacture;
    - Beamlineinstallation;

- Target installation on the channel;
- Development of air and liquid cooling systems for the target (task-dependent);
- Cooling system installation.

These measures enabled the production of neutrons with energies ranging from 20 keV to 15 MeV.

11. Calculation and design work for the manufacture of accelerator tube components:
    - Calculation of the accelerator tube and ion source interface unit;
    - Design of interface units for accelerator tube sections;
    - Manufacture of accelerator tube electrodes;
    - Manufacture of accelerator tube insulators.

(This fulfills modernization plan requirements for achieving target beam parameters).

12. Completion of scheduled preventive maintenance for accelerator nodes and systems. Mechanical units and assemblies were disassembled, restored, tested, and launched into design operating modes;
13. Design of the rotating mechanism for the beam transport device.

2025

1. **Personnel safety and fulfillment of ROSPOTREBNADZOR requirements** for the resumption of ESA operation. This included the inspection, maintenance, and necessary replacement of **beam probecables**, and updating the connection diagrams for the subsequent integration of the new **interlock system**. The interlock system was connected to the PNIPs and the protective doors of Hall No. 1, the EMA Hall, and Hall No. 2. (A mandatory condition for obtaining the **Sanitary-Epidemiological Conclusion (SEC)** and the operational permit)."
2. Repair and setup of the remote communication system based on PGS-3 (Experimental Hall No. 1, control room) (Personnel safety measure);
3. Painting of the beamline in the Left Experimental Hall in a bright color;
4. Installation of protection and signaling for potentially dangerous areas in the Accelerator Hall (completed in the Left Experimental Hall);
5. **High-Voltage and Beam Transport System:** Repair (restoration) of the accelerator transport belt charge-exchange voltage multiplier unit (Ensuring beam current stability);
6. Laying of new power and control lines for the connection of digital control and indication instruments for the EG-5 console (Accelerator control automation);
7. Development of design documentation, manufacture, and installation on Channel No. 3 of a remote control system for the quartz plate position drive (Safety and minimization of personnel time in active zone);
8. Development of manual and automatic control circuits for the fore-vacuum storage system (fore-tank). Automationoffore-vacuumoperation;
9. Compilation and approval of the routing scheme for accelerator power and control cables;
10. Tuning of ion beam current indication modes based on integral measurement;
11. Verification and alignment of accelerator energy operation modes. In collaboration with Yu.M. Gledenov, the compliance of operating modes with output energy parameters was checked; results showed no discrepancies, energy output matches specified settings;
12. Assembly of the power electronics rack for the Channel No. 1 ion beam scanning system in the Left Experimental Hall;
13. Replacement of bearings on the transport belt shafts;
14. Preventive maintenance, repair, and service of backup autotransformers, backup charge-exchange multiplier, and the mobile belt tensioner unit. Restorationofnodestofactoryparameters;
15. Manufacture and installation of a beam positioning system to improve transmission through the beamline after the measuring magnet;
16. Cleaning of the high-voltage terminal surface (coronating triode area) and column gradient ring insulators with solvent and hydrofluoric acid (to minimize H^+ion recombination);
17. Cleaning of the charging belt;
18. **Gas-Handling System (GHO):**
    - Dismantling of the 2R 3/220 high-pressure compressor;
    - Restoration of the concrete base for the installation of the VSHV-3/100 high-pressure compressor;
    - Installation and startup of the VSHV-3/100 (overcoming the ROSTEKHNADZOR ban on the gas-compressor unit operation);
    - Personnel training and certification for compressor operation;

19. **Ion Source:**

o Development and manufacture of the physical interface scheme for the ion source and the existing accelerator tube. Installation of the new source on the existing tube to obtain a more stable and powerful beam;

20. Cosmetic renovation of Rooms 130, 122, 119, 118, and 116 in Building 120; organization of new workstations;

21. **Organizational Measures:** Ensuring all necessary measurements and equipment tests are conducted to obtain the sanitary permit for EG-5 operation;

22. Received the FMBA conclusion for the SEC for EG-5 premises;

23. Installation and startup of the new compressor completed;

24. Documentation package prepared for the resumption of EG-5 ESA operation.

2026 (2026 (results at the time of report)

1. **Automation of ESA Technical Systems:** Connection of new instruments installed in the EG-5 console. Transitionpanelsforvacuummeasurementinstruments (Vacuumsystemautomation);

2. Creation of a remotecontrol system for the quartz plate position drive on Channel No. 3 (Beam transport automation);

3. Development of the automatic startup scheme and cable routing for the fore-vacuum storage (fore-tank) line (Vacuum system automation);

4. Preventive maintenance of backup autotransformers;

5. Preventive maintenance of the backup charge-exchange multiplier;

6. Setup of the intercom system based on PGS-3 (Experimental Hall No. 1, control room);

7. Tuning of ion beam current indication mode based on integral measurement;

8. Optimization of the ion source induction coil geometry;

9. **Personnel Safety:** Inspection of Ion Beam Monitoring Device cables and update of connection schemes for further interlock system integration (Ion Beam Monitoring Devices, Hall No. 1, EMA Hall, Hall No. 2);

10. **Organizational Activities:** Preparation of the documentation set for the SES conclusion for activities involving ionizing radiation sources:

- o Equipment layoutplan.
- o General diagram of the facility at the time of commissioning.
- o Fundamental schematic diagram of the facility.
- o Equipment layoutplan;
- o General facility diagram at commissioning;
- o Schematiccircuitdiagram;
- o Test protocols and electrical equipment checks;
- o Detailed interlock and signaling diagrams;
- o Acceptancecertificateafterinstallation;
- o Test protocols for mechanisms, equipment, and ventilation;
- o Groundingcheckprotocols;
- o Hiddenworkcertificates;
- o Operatinginstructions;
- o Labor safety and radiation safety instructions;
- o Calculated and experimental data confirming component operability;
- o List of necessary protective equipment;
- o Copies of orders appointing responsible persons for safe operation and radiation safety;
- o Orders for personnel authorized to work at the facility;
- o Laborsafetylogbook;
- o Updated EG-5 ESA passport, etc.

11. Receipt of project documentation for the accelerator protection and interlock system;

12. Receipt of project documentation for the ASRK system (automatic radiation control);

13. Receipt of project documentation for the VSHV 3/100 compressor unit;

14. Receipt of the ROSPOTREBNADZOR license;

15. Personnel training under the "Compressor Unit Operator" program;

16. Commencement of accelerator operation in debugging and system check mode.

Conclusion

During the modernization period, almost all fundamentally important systems, mechanical, and electronic units of the accelerator were repaired and updated. This allowed for the achievement of ion beam current parameters specified in the 1965 design (confirmed by documents). The replacement of oil vacuum pumps with higher-performance oil-free ones ensured the necessary channel cleanliness, raised the maximum vacuum in the beamlines to 5^{-7} mbar, and increased the maximum ion beam energy to 3.5 MeV.

Currently, almost all permits for the resumption of operation of the ESU are in place, with the exception of the project for connecting a new LPG compressor (PromExpertiza).

2.3. Status and stage (TDR, CDR, ongoing project) of the project (including percentage of implementation of the declared milestones of the project (*if applicable*)

Detailed list of planned measures with implementation status:

1. Measures to increase the operational safety of the accelerator

1.1. Painting the beamline in the Left Experimental Hall in a bright color — Completed
1.2. Installation of protection and signaling for potentially dangerous areas in the Accelerator Hall (Left Experimental Hall) — Completed
1.3. Installation of fencing around open technological hatches on the removable repair platform of the accelerator — Completed
1.4. Modernization of the radiation control and interlock systems — Completed
1.5. Repair of rotating doors in the Left Hall and the EMA Hall — Completed
1.6. Radiation shielding of the partition in Test Hall No. 3 — Completed

2. Measures to increase the dielectric strength of the accelerator's gas media, including indoor air

2.1. Repair and bringing service rooms into compliance with sanitary standards, ensuring ISO-9 cleanliness standards — Partially completed
2.2. Installation of oil inlet filters in the dielectric gas preparation system — Partially completed
2.3. Addition of SF6 (sulfur hexafluoride) to the nitrogen gas mixture — Completed
2.4. Installation of a gas supply system with atomic drying (achieving a 60% drying limit) — Completed
2.5. Elimination of leaks in cylinders and the insulating gas system — Completed
2.6. Fabrication and installation of a nitrogen trap before the sample chamber to capture oil vapors — Completed
2.7. Transition to turbomolecular pumps — Completed
2.8. Repair of the compressor / replacement of gas-handling equipment for nitrogen production and drying; updating cylinders — Completed
2.9. Installation of an SF6 processing and storage system — Completed

3. Verification of all accelerator systems, elimination of factors degrading performance, and preparation for high-voltage tube replacement

3.1. Floor repair, elimination of the analyzing magnet tilt; beam horizontal deviation compensation using permanent magnets — Not completed
3.2. Alignment check of the magnetic analyzer chamber with the beamline — Completed
3.3. Verification of beam shape and size at the inlet and outlet of the accelerator tube — Completed
3.4. Fabrication and installation of a beam positioning system after the measuring magnet — Partially completed
3.5. Surface cleaning of the high-voltage terminal, column insulators, and gradient rings using solvents and hydrofluoric acid — Completed
3.6. Cleaning of the charging belt — Completed
3.7. Smoothing the transition between column shield diameters to level the field gradient and eliminate breakdowns — Not completed
3.8. Strengthening the insulation of the tube-holding springs using Teflon tubes — Completed
3.9. Adjustment (in a single plane) and partial replacement of needles in the coronating triode — Completed
3.10. Adjustment of the discharge brush gap — Completed
3.11. Configuration change of charge-exchange brushes (dividing monolithic plates into three sections to reduce belt wear) — Not completed

3.12. Annealing and polishing of the diaphragm for ion beam shaping — Not completed
3.13. Revision of voltage divider resistors; replacement of resistors on the compensating section — Completed
3.14. High-voltage conditioning of the source to achieve target current — Completed
3.15. Installation of an external slit size control system, dynode ring for secondary electron suppression, and forced cooling in the energy stabilization system — Not completed
3.16. Optimization of the ion source induction coil geometry — Completed
3.17. Alignment of existing ion source optics with the tube outlet parameters — Completed

4. Replacement of the accelerator tube, resistive divider, and ion source with support from BINP SB RAS — Not completed
4.1. Testing the high-voltage tube with the divider and source; bringing the accelerator to standard mode — Not completed

5. Renovations in Experimental Halls
5.1. Cosmetic renovation in the Left Experimental Hall — Completed
5.2. Installation of a passive vibration damping system (base plates for the microbeam spectrometer on a sand cushion) — Completed
6. Installation of the reinforced concrete frame for the sample preparation laboratory — Not completed
7. Modernization of service equipment and automation for microbeam and neutron applications — Not completed
7.1. Automation of the spatial beam stabilization system — Partially completed
7.2. Replacement of obsolete instruments on the control console — Partially completed
7.3. Development and installation of a high-performance IBA chamber (RBS, ERD, PIXE) — Partially completed
8. Personnel training (young specialists), international cooperation, and user program organization — Partially completed
9. Equipping infrastructure with complementary methods (electrical, electronic, and optical properties) — Partially completed

Other
10. Restoration of technical documentation (design drawings) for the accelerator tube — Completed
11. Fabrication of an additional vacuum port in the upper vessel part (differential column pumping) — Not completed
12. Sample prep lab installation (finishing, utilities, and equipment) — Partially completed
13. Installation of a beam spreading and homogenization system (200 mm diameter) — Completed
14. Installation of a beam coordinate monitoring system with data logging — Not completed
15. Purchase of spare belts — Not completed
16. Setup of an experimental area for tube fabrication and bonding — Not completed
17. Fabrication of a super-stable ion source (<10 eV spread) and consideration of a Penning source for He^{2+}beams — Completed
18. Replacement of PVA glue in tube joints with low-outgassing alternatives — No relevant
19. Replacement of obsolete vacuum gauges with semiconductor analogs — Completed
20. Installation of remote beam monitors (Faraday cup, quartz screen, video camera) — Completed
21. Transition to remote-controlled vacuum gate valves for emergency isolation — Partially completed
22. Certification of the pressure vessel and all ESA systems — Completed
23. Replacement of power and control cables — Completed
24. Replacement of the analyzing magnet cooling system with a closed-cycle system — Partially completed
25. Development of the implementation plan based on the 2015 Nuclear Microprobe project — Partially completed
26. Ordering key components from FLNP workshops — Completed
27. Excavation for fast neutron experiments in the Right Experimental Hall — No relevant
28. Automation of technical systems of the ESA. Connection of newly installed instruments for the EG-5 control console. Transition panels for vacuum measurement instruments. (Automation of the vacuum system) — Completed.

29. Creation of a remote control system for the quartz plate position drive on channel No. 3 (Automation of the beam transport system) — Completed.
30. Development of the automatic activation circuit and the cable routing scheme for the vacuum line of the fore-vacuum storage tank (fore-tank) (Automation of the vacuum system) — Completed.
31. Organizational activities. Preparation of a documentation set to obtain the Sanitary-Epidemiological Service (SES) conclusion for carrying out activities in the field of using Ionizing Radiation Sources (IRS) — Completed.
32. Obtaining project documentation for the accelerator protection and interlock system — Completed.
33. Obtaining project documentation for the Automatic Radiation Control System (ASRK) — Completed.
34. Obtaining project documentation for the gas compressor unit / VSHV 3/100 compressor — Completed.
35. Obtaining the license from ROSPOTREBNADZOR — Completed.
36. Personnel training — Completed.
37. Commencement of accelerator operation in debugging and system verification mode — Completed.

Critical Analysis of Project Results

The project goal has not been fully achieved due to the inability to implement the microbeam spectrometer and high-intensity ion beam experiments using the basic ESA configuration. However, technical capabilities for the JINR Topical Plan (PTP) scientific program regarding fast quasi-monoenergetic neutrons and elemental analysis have been established.

Task 1 is partially completed as sufficient beam luminosity has not yet been achieved. Core updates (vacuum system, oil pump elimination, turbomolecular pumping) were performed. Modernization of the gas-handling system addressed the 2014 ROSTEKHNADZOR injunctions. A modern MWIS (Microwave Ion Source) from BINP SB RAS was delivered. Beam current was increased to 30 μA (100% of design value) and energy to 3.5 MeV (85% of design value). Key unresolved issues include the automation of most systems and the bonding/installation of the new accelerator tube. The primary delay factor of Task 1 is the indefinite postponement of tube bonding by BINP SB RAS.

Task 2 (Experimental infrastructure) is partially completed. A solid-state Li-target was installed, and the irradiation chamber was modified. Sample prep lab renovations in Building 120 are ongoing. High-resolution HD-2000 and other lab equipment were purchased. Delays are primarily due to the failure of FLNP technical services to fulfill electrification and repair requests.

Task 3 (Organizational tasks) is largely completed. The main organizational tasks aimed at the resumption and subsequent productive operation of the accelerator complex have been practically fulfilled. In particular, the long-standing problem of the gas compressor station shutdown due to the reduced strength of 200 atm cylinders has been resolved (1). Multiple meetings were held, including at the level of directors, regarding the assistance of the Budker Institute of Nuclear Physics (Novosibirsk) with the EG-5 ESA modernization activities at FLNP JINR (2); zoning of the accelerator complex premises has been conducted, and radiation hazard classes have been assigned in accordance with the new technical parameters of the ESA (3); radiation control and interlock systems have been installed and commissioned (4), repair of carousel-type doors to the experimental halls has been performed (5), a set of necessary documents and other preparatory works has been prepared, which allowed for obtaining the Sanitary-Epidemiological Conclusion (SEC) for the accelerator and experimental halls of the accelerator complex (6), as well as the ROSPOTREBNADZOR license for working with ionizing radiation sources (7).

Within the Division of Nuclear Physics (DNP) of the Frank Laboratory of Neutron Physics (FLNP), the Sector of Nuclear Physics Materials Science and Ion-Implantation Nanotechnologies (8) has been formed, which includes a team of technical specialists (the Group for Scientific and Technical Support of Nuclear Physics Experiments) and scientists specializing in accelerator-based research methods and scientific topics related to the accelerator. The Sector, within the framework of an extensive international collaboration, produces more than 20 scientific publications annually, one-third of which are in top-tier journals of the Q1 and Q2 quartiles.

The key event preventing the resumption of accelerator operation in its basic configuration (along with the gas compressor station) during the reporting period is the non-fulfillment of obligations regarding the deadlines for the compressor installation project by "Promexpertiza" LLC.

Conclusions

The overall status is reflected in the diagram (Fig. 2).

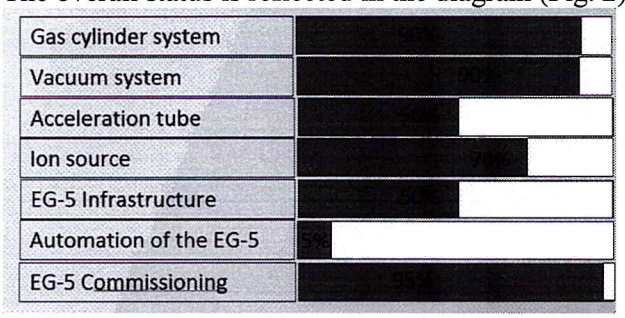


Fig. 4.2. General state of the EG-5 ESA modernization process in the form of a diagram.

Modernization of the gas-handling equipmentand vacuum systems is nearly finished. The ion source is available but requires integration with the tube. The accelerator tube requires bonding and installation. Experimental spectrometers in the Left Hall are operational. Substantial expansion of the technical group is required for the completion of the project.

2.2. A detailed scientific report

2.2.2. A description of the experiments carried out (for pilot projects).

2.2.3. A description of the scientific work undertaken and the results obtained.

2024

1. INVESTIGATION OF THE INFLUENCE OF PROTON IRRADIATION ON THE DISTRIBUTION PROFILE OF Pt AND Cr IN THE SURFACE LAYERS OF n-Si<Pt>, n-Si<Cr> BY THE METHOD OF ELLIPSOMETRIC SPECTROSCOPY (ES)

With the use of the Method of Rutherford Backscattering (RBS) was investigated atomic porosity of crystals CaF_2, doped with ErF_3 (CaF_2 + x%mol ErF_3, where x= 2.0 and 5.5%), obtained with use of the Bridgman method. It is shown, that the volume of pores constitutes 18 - 22% from the total volume of the material, and their sizes are located within the limits of 2.4×10^{18} - 3.0×10^{18} atoms per cm^2 [1].

[1] Tuan Phan Luong, Kulik Mirsolaw, Stef Marius, Phuc Tran Van, My Nguyen Thi Bao, Zelenyak Tatyana Yuryevna, Buse Gabriel, Racu Andrei, Doroshkevich Aleksandr, Khiem Le Hong, Cong Vu Duc, Lyubchyk Andriy IgorevychLyubchyk, SergiyIgorevich, Lyubchyk Svitlana Borisovna, Anh Nguyen Ngoc. An examination on the porosity of ErF3 doped CaF2 crystal using the Rutherford back-scattering method. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms. Volume 547, February 2024, 165178, https://doi.org/10.1016/j.nimb.2023.165178. (Q3, IF=1,4).

Investigated the influence of high-temperature doping and proton irradiation (energy 2 MeV, dose 5.1×10^{14} cm^{-2}) on the depth profile and formation of layers on the surface of monocrystalline silicon of n-type, doped with phosphorus and platinum / chromium. Investigation of optical properties of the surface of samples was conducted with the help of ellipsometer ELLIPS-1991 (RF). Established the presence of oxide layers on the surface of initial and irradiated samples. It is established that the thickness of surface layers in samples of silicon, doped with chromium, is almost 2 times larger, than in samples of silicon, doped with platinum. It is shown, that the increase of dose rate leads to decrease of the thickness of the oxide layer on the surface of silicon samples, supposedly, due to radiation disruption of their crystal structure [2].

[2] UtamuradovaSh.B., Rakhmanov D.A., Tuan P.L., Doroshkevich A.S., Isayev R.Sh., Abiyev A.S., Studying the influence of proton irradiation on the distribution profile of Pt and Cr in surface layers n-Si<Pt>, n-Si<Cr> using ellipsometric spectroscopy Advanced Physical Research, Vol.6, No.2, 2024, pp.83-89, https://doi.org/10.62476/apr62.83

2025

2. STRUCTURAL PROPERTIES AND ELECTRICAL CONDUCTIVITY OF SnOxFILMS: INFLUENCE OF HELIUM ION IRRADIATION

The influence of implantation of He^+ ions with energy 2.4 MeV at various fluences ($3.75 \cdot 10^{14}$ cm^{-2}, $1.1 \cdot 10^{15}$ cm^{-2} and $1.1 \cdot 10^{16} cm^{-2}$) into thin films of tin oxides on their structural properties and value of electrical conductivity σ was studied. Films of tin oxides were obtained by the method of magnetron sputtering of tin with subsequent two-stage annealing in air: at 200 °C for 2 hours during the 1st stage and at 350 °C for 1 hour during the 2nd. According to the results of X-ray structural analysis, after annealing the films have a polycrystalline structure with the presence of SnO and SnO_2 phases in their composition. It was established that the implantation of He^+ ions at a fluence of $3.75 \cdot 10^{14} cm^{-2}$ leads to insignificant structural changes in the tin oxide film, however the value of σ at the same time increases by approximately an order of magnitude (from 0.11 to 1.1 $\Omega^{-1}cm^{-1}$), which is explained by an increase, as a result of implantation, in the concentration of oxygen vacancies and interstitial tin, which are electron donors. During the implantation of He+ ions into tin oxide films at higher fluences ($1.1 \cdot 10^{15}$ and $1.1 \cdot 10^{16}$ cm^{-2}), the change in the electrical conductivity σ of the films, along with the introduction of additional donor centers, is influenced by the disordering of the film structure, the consequence of which is a less significant increase in the value of σ (from 0.11 to 0.36 and 0.30 $\Omega^{-1} \cdot cm^{-1}$, respectively).

The work was performed within the framework of the JINR — Belarus cooperation program (order No. 234 dated 21.03.2025, item 19) and within the framework of task 3.02.1.4 of the State Program for Scientific Research of the Republic of Belarus "Convergence-2025".

[1] V.K. Ksenevich, V.A. Dorosinets, M.A. Samarina, D.V. Adamchuk, A.I. Kruglyak, P.L. Tuan, R.S. Isayev, A.S. Doroshkevich. "Structural properties and electrical conductivity of SnOx films: influence of helium ion irradiation", Interaction of Radiation with Solids: materials of the 16th Intern. conf., Minsk, Belarus, Sept. 22–25, 2025 / Belarus. State Univ.; editorial board: V. V. Uglov (editor-in-chief) [et al.]. – Minsk: BSU, 2025. – 279 p

3. FAST NEUTRONS IN LOW DOSE AS A PRIMING TOOL FOR INCREASING THE TOLERANCE OF TRITICALE (X TRITICOSECALE) TO ABIOTIC STRESSES

An investigation of the impact of fast neutrons (accelerator EG-5, JINR, Dubna) in various doses on triticale seeds was conducted. The main criterion for the selection of the threshold (priming) dose was the absence of statistically significant inhibition of morphophysiological parameters (length of roots and shoots).

It was established that the dose of 5 Gy is the threshold one: it did not exert a reliable negative influence on the growth indicators of seedlings, in contrast to higher doses, which caused significant inhibition. Therefore, it was identified as the best candidate as an effective tool for an adaptive response.

At the present time, experiments are being conducted to test the hypothesis that pre-sowing treatment of seeds with fast neutrons at the selected dose forms cross-tolerance to various abiotic stresses. This approach has significant potential for practical application in breeding and seed production.

[2] A.I. Kruglyak, Yu.V. Alekseenok, P.Yu. Volkova, A.S. Doroshkevich, A.A. Soloviev. Fast neutrons in low dose as a priming tool for increasing the tolerance of triticale (x Triticosecale) to abiotic stresses. Tasks and methods of neutron research of condensed media: V All-Russian scientific-practical conference (with international participation) (Dubna, November 24–27, 2025): collection of abstracts / under the general editorship of V. I. Bodnarchuk. – Dubna: State University "Dubna", 2025. – p. 21.

4. IMPACT OF IRRADIATION AND THERMAL TREATMENTS ON CUO NANOSTRUCTURES: DEFECT FORMATION AND STRUCTURAL ANALYSIS.

Columnar structures of CuO composition (Fig. 4.3) were synthesized by the method of structural design with subsequent accelerator modification (He^+ ions, E=2 MeV, maximum dose D = 3.38×10^{16} particles/cm^2), intended for promising functional heterostructures of high-efficiency solar cells, optoelectronic devices, and X-ray radiation detectors.

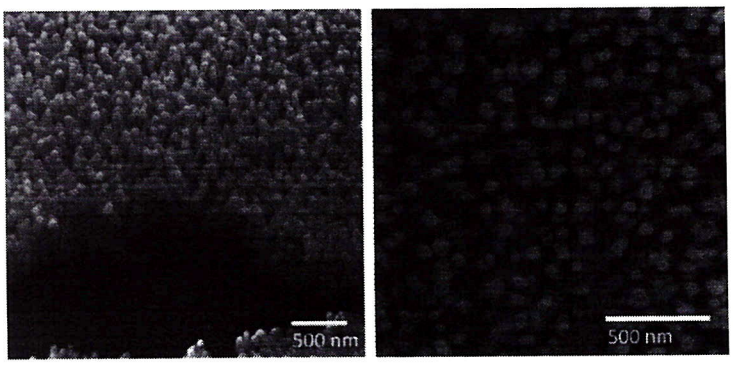


Fig. 4.3. Images of CuO nanostructures obtained with the help of scanning electron microscopy (SEM).

Scanning electron microscopy (SEM) (fig. 4.3), X-ray diffraction (XRD) (fig. 4.4), and positron annihilation spectroscopy (PAS) (fig. 4.5) revealed competing processes of formation and regeneration of defects in the surface highly defective layer of the nanorods. It was established that at low doses, irradiation by high-energy He^+ particles leads to the formation of a large number of defects in the material of the nanorods, while at higher doses, a transition occurs to saturation of the process of vacancy formation, their complexation, and regeneration of the crystal lattice (electronic annealing).

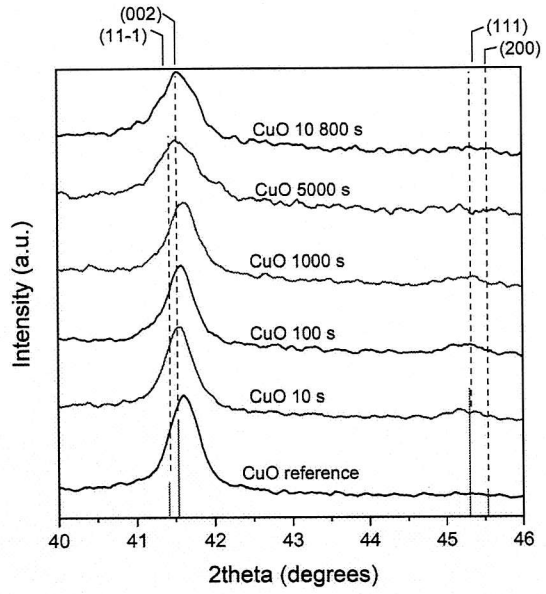


Fig. 4.4. X-ray diffraction patterns of columnar CuO structures obtained at different irradiation times.

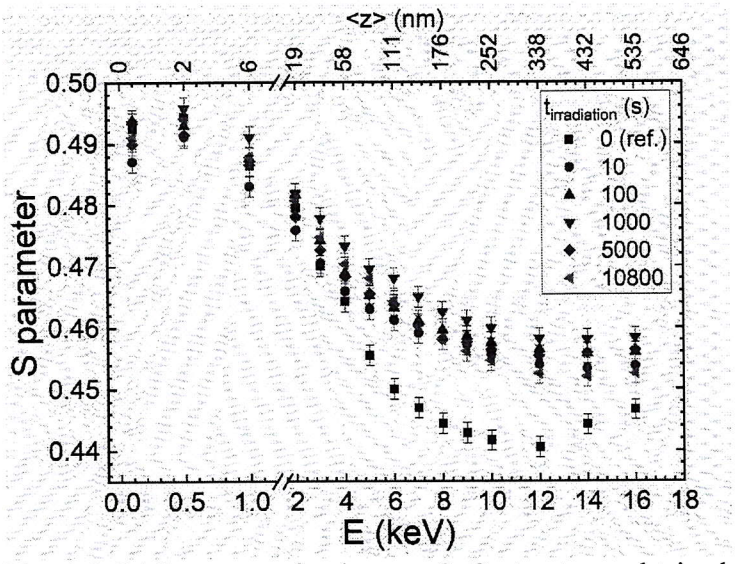


Fig. 4.5. PAS spectra of columnar CuO structures obtained at different irradiation times. The structural evolution of the considered objects was studied in detail using the methods of electron microscopy and X-ray structural analysis.

5. INFLUENCE OF NEUTRON IRRADIATION ON AGGREGATE- AND DISPERSION-HARDENED STRUCTURE OF COMPOSITE ZTA-CERAMICS

The influence of neutron irradiation on the aggregate- and dispersion-hardened structure of composite ceramics of composition α-Al_2O_3 + n%YSZ (ZrO_2 + 3 mol.%Y_2O_3) (n = 0; 1; 5; 10 and 15 wt.%), obtained as a result of processing compacts with high hydrostatic pressure of 300 and 700 MPa, was investigated. X-ray structural analysis showed that neutron irradiation of the two-phase ceramics did not cause phase changes in the ceramic composite. In the course of the work, it was established that the effect of grain crushing in the material is observed only in relation to YSZ particles and is not observed in relation to α-Al_2O_3 grains, which may be connected with the structural features of the crystal lattices of α-

Al_2O_3 and t-ZrO_2. The research results allow speaking about the prospects of using the studied ceramics under conditions of radiation exposure.

[3] A.V. Maletsky, R.Sh. Isayev, D.R. Belichko, G.K. Volkova. Influence of neutron irradiation on aggregate- and dispersion-hardened structure of ZTA composite ceramics // VoprosyMaterialovedeniya (Materials Science Issues). – 2025. – No. 2 (122). – pp. 130-152.

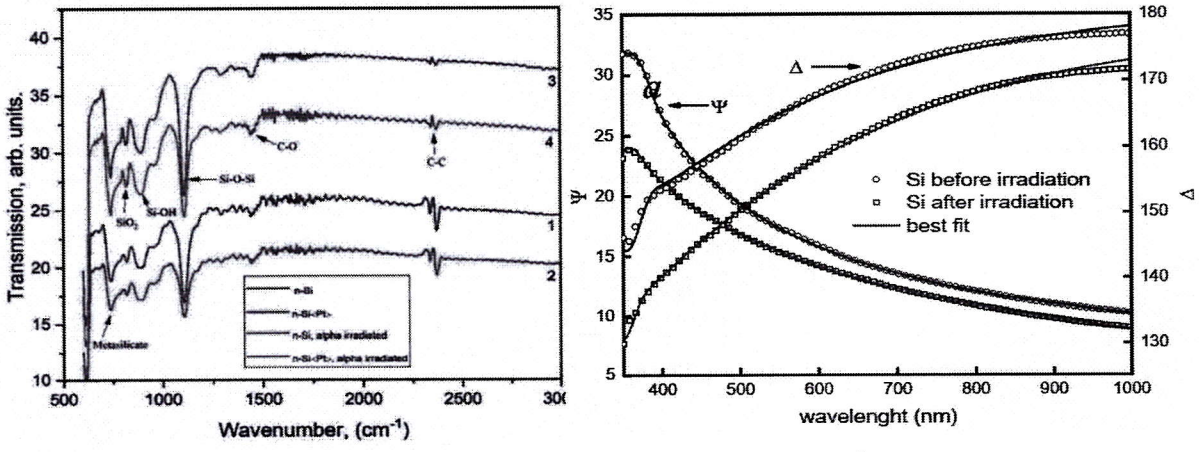
6. STRUCTURE AND MECHANICAL PROPERTIES OF ELECTROLYTIC CHROMIUM COATINGS DEPOSITED ON THE INNER SURFACE OF FUEL CLADDING MADE OF EP823-Sh STEEL

The structure was investigated and the main mechanical properties of electrolytic chromium coatings deposited on the inner surface of fuel cladding made of ferritic-martensitic steel EP823-Sh were determined. It is shown that the optimal temperature of the electrolytic bath for deposition of hard dense coatings without cracks is a temperature of 30-35 °C at a current density of 0.15 – 0.18 A/cm^2. It is shown that at a higher temperature, columnar fine-disperse chromium crystals are deposited, texture appears and microcracks are formed, which reduces the protective properties of the coating. It is shown that the chromium coating at the initial stage of abrasive action increases the resistance to wear of the inner surface of the fuel cladding nearly 3 times. This indicates that when filling the chromium-plated cladding with pelletized fuel, its inner surface will have less mechanical damage and, accordingly, have greater corrosion resistance compared to the fuel cladding without coating.

[4] Elmanov, G. N., Isaev, R. S., Dzhumaev, P. S., Yakovleva, A. D., Loginov, B. A., &Naumenko, I. A. (2025). Structure and Mechanical Properties of Electrolytic Chromium Coatings Deposited on the Inner Surface of Fuel Cladding Made of EP823-Sh Steel. Inorganic Materials: Applied Research, 16(5), 1324-1332.

7. INFLUENCE OF ALPHA PARTICLES ON TECHNOLOGICAL IMPURITIES IN SILICON DOPED WITH PLATINUM

The influence of alpha particles on the concentration of optically active oxygen in silicon samples doped with platinum was investigated, and radiation defects arising after irradiation with alpha particles were determined. Silicon samples were doped with platinum, after which irradiation with alpha particles with energy 2 MeV was conducted; the dose amounted to $5 \cdot 10^{14}$ cm^{-2}. Individual peaks testifying to the presence of various types of chemical bonds were detected. IR spectra show (Fig. 4.6a) that doping with platinum atoms leads to a decrease in the concentration of optically active oxygen by almost 2 times due to the formation of the Pt-O compound in silicon after doping.



a b

Fig. 4.6 IR spectra (a) of n-type monocrystalline silicon before (curve 1) and after (curve 2) doping with Pt and irradiation with alpha particles (curves 3 and 4, respectively). Data of spectral ellipsometry before and after irradiation of n-type monocrystalline silicon (b).

It is shown that alpha-irradiation creates radiation defects and destroys the Pt-O compound in silicon. The investigation by the method of ellipsometric spectroscopy showed (fig. 4.7) that in the initial samples only an oxide layer with a thickness of 5.38 nm was observed. After diffusion doping, besides the oxide layer, one more layer with a thickness of 30.4 nm was formed.

[5] Utamuradova, Sh.B., Rakhmanov, D.A., Tuan, P.L., Doroshkevich, A.S., Kinev, V.A., Tatarinova, A., Isayev, R.Sh., Abiyev, A.S. (2025). Influence of alpha particles on technological impurities in silicon doped with platinum. New Materials, Compounds and Applications, 9(1), 50-57

8. INTERACTION OF CHROMIUM COATING WITH FUEL CLADDING MADE OF EP823-Sh STEEL IN THE TEMPERATURE RANGE 420-650 °C

The diffusion interaction of chromium coating and steel during high-temperature tests was investigated. Electron-microscopic investigations of samples after high-temperature tests showed the presence of a "coating-steel" interaction layer. It was established that at a temperature of 420 °C and a holding time of 1000 h, the chromium coating retained adhesion; interaction between the coating and the steel was not observed. The appearance of an interaction layer uneven in thickness within 150-600 nm was established at the "coating-steel" boundary after thermal treatment of the coating at T = 540 °C and 650 °C for 1000 h (Fig. 4.7). This layer has a complex composition and blocks further mutual diffusion of components of the steel and the coating into each other. EP823-Sh steel contains molybdenum and tungsten at about 1 wt. %, and these elements may contribute to the accelerated formation of the interaction layer. Analysis of the interaction in the "coating-steel" system showed the prospects of using chromium as a protective coating for the inner surface of the fuel cladding made of EP823-Sh steel.

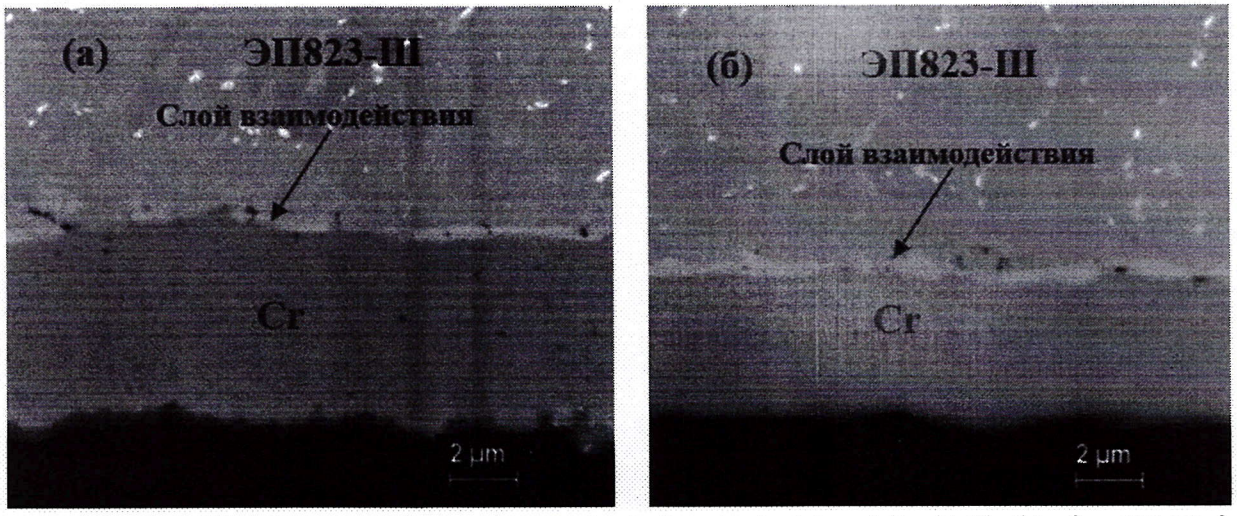


Fig. 4.7. SEM images of the coating-steel interface in Ar (a) and liquid Pb (b) after 650 °C for 100 h.

[6] Isayev, R. S., &Dzhumaev, P. S. (2024). Interaction of Chrome Coating with Cladding Made of EP823-Sh Steel in the Temperature Range 420–650° C. Physics of Atomic Nuclei, 87(11), 1689-1695.

2.2.4. A list of the main publications of JINR authors, including associated personnel on the results of the project work (list of bibliographical references).

2.2.5. A complete list of publications (electronic annex, for journal publications with journal impact factor).

2024

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2. Belichko D.R., Volkova G.K., Maletskii A.V., Isayev R.Sh. Influence of proton irradiation on the structure and properties of composite ceramics of YSZ-SiO□-Al□O□ composition // VoprosyMaterialovedeniya (Materials Science Issues). – 2024. – No. 3 (119).
3. Belichko D.R., Maletskii A.V., Volkova G.K., Yakimenko M.N., Kovalev O.E. "The role of hafnium oxide in the process of structure formation of zirconia-based ceramics". Conference materials: II All-Russian Conference with International Participation "Modern Methods of Materials Preparation, Surface Treatment and Coating Application (Materials Science–2024)", pp. 141-147, March 28-29, 2024, Kazan, Russia.

4. Dobromir E., DoroshkevichAlexandr, and Yildiz Abdullah. 2024. "Electrical Conduction Mechanism of Mg-Doped ZrO2 Thin Films" Materials 17, no. 15: 3652. https://doi.org/10.3390/ma17153652
5. Didenko E.A., Doroshkevich A.S., Gremenok V.F., Oksengendler B.L. Electrical effects in nanostructured materials based on CuIn(Se,S)□ under the influence of humidity and illumination; edited by A.N. Voropai. – Dubna State University, 2024. – 95, [66-67] p. ISBN 978-5-89847-719-6.
6. Didenko E.A., Doroshkevich A.S., Gremenok V.F., Oksengendler B.L. Electrical effects in nanostructured materials based on CuSn(S,Se)□ under the influence of humidity and illumination / Proceedings of the II ALL-RUSSIAN CONFERENCE WITH INTERNATIONAL PARTICIPATION "INNOVATIONS IN ALTERNATIVE ENERGY: PRODUCTION AND ACCUMULATION", November 18-19, 2024, Dubna University, Dubna, RF. pp. 66-67.
7. Doroshkevich A.S., Kirillov A.K., MezentsevaZh.V., Oksengendler B.L., SuleimanovS.Kh., Didenko E.A., Parpiev O., Gremenok V.F. PHYSICAL MODIFICATION AND INVESTIGATION OF FUNCTIONAL STRUCTURES FOR ELECTRONICS USING THE METHODOLOGICAL BASE OF THE EG-5 ACCELERATOR COMPLEX AT JINR / Proceedings of the "Ninth International Conference on Physical Electronics IPEC-9", Arifov Institute of Ion-Plasma and Laser Technologies, Academy of Sciences of Uzbekistan, October 3-4, 2024, Tashkent. pp. 92-94.
8. Doroshkevich A.S., MezentsevaZh.V., Oksengendler B.L., Didenko E.A., Kibardina E.A., Gremenok V.F., Kirillov A.K., Vasilenko T.A., Balasoui M.A., Cornei Nicoleta, Mardare Diana, Mita Carmen, Mirzayev M.N., Popov E.P., Jovanovic Zoran, Teofilović Vesna, Ristić Ivan, Tuan Phan Luong, Chicea Dan, AppazovNurbol, Parpiev O. Development of adsorption energy and electronics devices based on ZrO□-nanopowder systems at JINR / Proceedings of the II ALL-RUSSIAN CONFERENCE WITH INTERNATIONAL PARTICIPATION "INNOVATIONS IN ALTERNATIVE ENERGY: PRODUCTION AND ACCUMULATION", November 18-19, 2024, Dubna University, Dubna, RF. pp. 68-70.
9. Isayev R. S., Dzhumaev P. S., Yakovleva A. D., et al. Corrosion resistance of chromium coating on the inner surface of EP823-Sh steel cladding // Nuclear Energy and Technology. – 2024. – Vol. 10. – No. 2. – pp. 81-88.
10. Isayev R., Natalia P., Evgeniy M., Dzhumaev P., Korenevski E. Corrosion of EP823 steel cladding under heavy liquid metal coolant reactor conditions: A review // Nuclear Science and Engineering.
11. Isayev R.Sh., Dzhumaev P.S. "Interaction of chromium coating with fuel cladding made of EP823-Sh steel in the temperature range of 420-650 °C" // Vestnik NRNU MEPhI. – 2024. – Vol. 13. – No. 4.
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13. Kruglyak A.I., Tuan P.L., Isayev R.Sh., Ksenevich V.K., Dorosinets V.A., Samarina M.A., Adamchuk D.V., Doroshkevich A.S. Influence of helium implantation on the structural properties of disordered tin oxide films / Materials and Structures of Modern Electronics: materials of the XI Intern. Scientific Conf., Minsk, Oct 16–18, 2024 / BSU; editorial board: V.B. Odzhaev (editor-in-chief) [et al.]. – Minsk: BSU, 2024. – pp. 74–79.
14. Maletskii A.V., Volkova G.K., Belichko D.R., Glazunova V.A., Doroshkevich A.S., Tatarinova A.A., Lyubchyk S.I., Lyubchyk S.B. Influence of stabilized zirconium dioxide and high hydrostatic pressure on the kinetics of sintering nanopowders of metastable aluminum oxide // Ceramics International 2024.
15. Maletskii A.V., Oksengendler B.L., Doroshkevich A.S., MezentsevaZh.V. "Electrochemical Impedance Spectroscopy of Planar Chemo-Electronic Energy Converters Based on YSZ Nanopowders". 2024 IEEE 25th EDM, Altai, RF. pp. 130-133.
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17. Mirzayeva D.M., Kaplina S.P., Gustova M.V., Kamanina I.Z., Anisimova O.V., Abiyev A.S., Asadov A.G., Doroshkevich A.S., Vladescu A., Jabarov S.H., Aliyev Y.I., Mehdiyeva R.N., Mirzayev M.N., Slavov L., Demir E., and Popov E. Modern Physics Letters B, Vol. 38, No. 02, 2350260 (2024).
18. Mirzayeva D.M., Aghayeva S.A., Kaplina S.P., Slavov L., Gustova M.V., Tiep N.V., Tuan P.L., Maletskii A.V., Doroshkevich A.S., Thabethe T.T., Hasanov K.M., Kostov L.K., Mauyey B. Mechanism of formation water molecules and chemical bonds in leptothrix materials. Advanced Physical Research Vol. 6, No. 1, pp. 5-14.
19. Maletskii A.V., Volkova G.K., Константинова T.E., Belichko D.R., Nosolev I.K., Doroshkevich A.S., MezentsevaZh.V., Oksengendler B.L., Teofilovic V., Erceg T., Ristic I. InfluenceofY□Al□O□□ onthestructureformationandpropertiesofAl□O□ - Y□O□ systemceramics. VoprosyMaterialovedeniya (Materials Science Issues), 2024, Vol. 118, No. 2, pp. 33-45.
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2.2.6. List of Presentations at International Conferences

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8. Doroshkevich Aleksandr, MezentsevaZhanna, Oksengendler Boris, Suleymanov Sultan, Didenko Ekaterina, ParpievOdilkhoja. Advanced nuclear physics and nanotechnological research on the base of the EG-5 accelerator at JINR // Third International Forum "Physics - 2024", Samarkand State University and Institute of Engineering Physics Samarkand, Uzbekistan, April 23-25, 2024 (Poster).
9. Doroshkevich A.S., Kirillov A.K., MezentsevaZh.V., Oksengendler B.L., Suleymanov S.H., Didenko E.A., Parpiev O., Gremenok V.F. Physical modification and study of functional structures for electronics using the methodological base of the EG-5 accelerator complex at JINR / Proceedings of the "Ninth International Conference on Physical Electronics IPEC-9", Arifov Institute of Ion-Plasma and Laser Technologies of the Academy of Sciences of the Republic of Uzbekistan, October 3-4, 2024, Tashkent. (Oralreport).
10. Doroshkevich Aleksandr. MATERIALS SCIENCE INSTITUTE SOLAR PHYSICS RESEARCH & DEVELOPMENT ASSOCIATION - INSTITUTE OF MATERIAL SCIENCES SCIENTIFIC PRODUCTION ASSOCIATION «Electron Nose: Acquisition and Modification of Hierarchically Nanostructured Oxide Active Materials for Advanced Biological Gas Sensor Project» Kick-off Meeting, October 7, 2024, FACULTY OF TECHNOLOGY NOVI SAD, Serbia. (Oralreport).
11. Isaev R.Sh., Dzhumaev P.S. "Electrodeposition of chromium-containing coating on the inner surface of fuel element claddings made of EP823-Sh steel without fluoride additives", All-Russian Scientific and Practical Conference "Fluoride Materials and Technologies", April 15-19, 2024, IGIC RAS, Moscow, Russia.
12. Isaev R.Sh., Dzhumaev P.S. "Preparation of chromium-molybdenum coating on EP823-Sh steel from an acid sulfate electrolyte", XIV Conference of Young Scientists on General and Inorganic Chemistry, April 09-12, 2024, IGIC RAS, Moscow, Russia. (Poster).
13. Isaev R.Sh., Dzhumaev P.S. "Interaction of chromium coating with EP823-Sh steel in the temperature range 420–650 °C", X All-Russian Conference with International Participation "Physico-Chemical Processes in Condensed Media and at Interfaces", dedicated to the 190th anniversary of the birth of D.I. Mendeleev, September 23–25, 2024, Voronezh, Russia (Poster).
14. Isaev R.Sh., Dzhumaev P.S., Staltsov M.S. "Radiation resistance of electrolytic chromium coating on the inner surface of the fuel element cladding made of EP823-Sh steel", XII International Conference on Reactor Materials Science dedicated to the 60th anniversary of the materials science complex of JSC "SSC RIAR", June 17–21, 2024, Kazan, Russia (Poster).

15. Isaev R.Sh., Dzhumaev P.S., Elmanov G.N. "Influence of hydrogen on the mechanical properties of chromium coating on EP823-Sh steel", 22nd International School-Conference "New Materials" named after B.A. Kalin (NM-2024). Moscow, NRNU MEPhI, October 15–17, 2024. (Poster).
16. Kalanda N.A., Yarmolich M.V., Petrov A.V., Semchenko A.V., Doroshkevich A.S., Kruglyak A.I., Isaev R.Sh. Features of oxygen exchange and radiation-stimulated oxygen diffusion in the structure of a complex metal oxide compound // VI International Scientific Conference "Problems of Radiation Interaction with Matter", November 14, 2024, Gomel, Belarus. (Poster).
17. Kruglyak A.I. 53rd International Tulinov Conference on the Physics of Charged Particle Interaction with Crystals – Evaluation of the effect of helium implantation on the properties of disordered tin oxide films by physical and nuclear-physical methods – MSU, Moscow – 2024 (Oral report).
18. Kruglyak A.I. V International Scientific Forum «Nuclear Science and Technologies» (15th International Conference «Nuclear and Radiation Physics», 4th International Conference «Nuclear and Radiation Technologies in Medicine, Industry and Agriculture) – Induction of variability in triticale (× Triticosecale) using fast neutrons – Almaty, Kazakhstan – 2024 (Oral report).
19. Kruglyak A.I., Tuan P.L., ZeleniakT.Yu., Ksenevich V.K., Dorosinets V.A., Samarina M.A., Adamchuk D.V., Doroshkevich A.S. Study of structural and magnetic properties of tin oxide films when doped with ferromagnetic metals. // Collection of materials of the III International Scientific Conference "Modern Trends in the Development of Semiconductor Physics: Achievements, Problems and Prospects". Tashkent (Uzbekistan), September 26-27, 2024. (Oralreport).
20. Kruglyak A.I. XI International Scientific Conference "Materials and Structures of Modern Electronics" MSSE – Influence of helium implantation on the structural properties of disordered tin oxide films – Minsk, Belarus – 2024 – (Poster).
21. Maletskii A.V., Doroshkevich A.S., Konstantinova T.E., Belichko D.R., Volkova G.K. Investigation of the mass transfer process at the initial stage of sintering and its influence on the structure of ZTA composite ceramics. In the collection of conference abstracts: VNKSF-28, Novosibirsk, April 1-6, 2024. (Oral report).
22. Maletskii A.V., Belichko D.R. Investigation of the mechanisms of the initial stage of sintering of a mixture of nanopowders of metastable aluminum oxide and stabilized zirconium dioxide. In the collection of conference abstracts: International Scientific Conference of Students, Postgraduates and Young Scientists "Lomonosov-2024", Moscow, April 12-26, 2024. (Poster).
23. Kibardina E.A. Effect of electric charge accumulation by hydrated nanopowder systems ZrO□ + 3 mol% Y□O□. Dependence on particle size. / Proceedings of the II ALL-RUSSIAN CONFERENCE WITH INTERNATIONAL PARTICIPATION "INNOVATIONS IN ALTERNATIVE ENERGY: PRODUCTION AND STORAGE" November 18-19, 2024, Dubna University, Dubna, RF. pp. 82-83. (Poster).
24. Kruglyak A.I., Tuan P.L., Doroshkevich A.S., Ksenevich V.K., Dorosinets V.A., Samarina M.A., Adamchuk D.V. Evaluation of the effect of helium implantation on the properties of disordered tin oxide films by physical and nuclear-physical methods // Abstracts of the 53rd International Tulinov Conference on the Physics of Charged Particle Interaction with Crystals, June 2024 / Lomonosov Moscow State University. EditedbyProf. N.G. Chechenin. (Poster).
25. Kruglyak A.I., Soloviev A.A., AleksiayenakYu.V., Doroshkevich A.S. Induction of variability in triticale (× Triticosecale) using fast neutrons // V International Scientific Forum «Nuclear Science and Technologies» (15th International Conference «Nuclear and Radiation Physics», 4th International Conference «Nuclear and Radiation Technologies in Medicine, Industry and Agriculture»), Republic of Kazakhstan, 2024. – p. 297. (Poster).
26. Kruglyak A.I. 31st All-Russian Scientific and Technical Conference with International Participation "Vacuum Science and Technology – 2024". (Poster).
27. Korenevskii E.L., Pukhareva N.A., Dokuchaev E.A., Isayev R.Sh., Dzhumaev P.S. «High-temperature oxidation study of E110 zirconium alloy coated with a protective Cr coating containing a multicomponent refractory diffusion barrier» 9th International Congress on Energy Fluxes and Radiation Effects 16-21 September, Tomsk, Russia. (Poster).
28. Maletskii A.V. The effect of mechanical influences on the sintering of ZTA composite ceramics. In the collection of conference abstracts: XXIX All-Russian Scientific and Practical Conference of Students, Postgraduates and Young Specialists, Dubna, April 22–26, 2024. (Oralreport).
29. Maletskii A.V. Influence of high hydrostatic pressure on the densification mechanisms at the initial stage of sintering of a composite mixture of metastable aluminum oxide. In the collection of conference abstracts: XI International Youth Scientific Conference "Physics. Technologies. Innovations. (FTI-2024)", Yekaterinburg, May 20-25, 2024. (Oralreport).
30. Maletskii A. V. The effect of mechanical influences on the sintering of ZTA composite ceramics. JINR Association of Young Scientists and Specialists Conference "Alushta-2024", June 9–16, 2024. (Oralreport).
31. Maletskii A. V., Belichko D.R., Doroshkevich A. S. Effect of proton irradiation on the structure and properties of the Al□O□-YSZ composite ceramics system. 28th International Scientific Conference of Young Scientists and Specialists (AYSS-2024), October 27 - November 1, 2024, JINR, Dubna, Russia. (Oralreport).
32. MezentsevaZh.V., Doroshkevich A.S., Maletskii A.V., Oksengendler B.L., Nikiforova N.N., Didenko E.A., Kirillov A.K., Mardare D., Mita K., Parpiev O.R., Suleymanov S.H. Electrical properties of the contact of hydrated nanoparticles of various sizes of YSZ composition under hydration and deuteration conditions / Proceedings of the II ALL-RUSSIAN CONFERENCE WITH INTERNATIONAL PARTICIPATION "INNOVATIONS IN ALTERNATIVE ENERGY: PRODUCTION AND STORAGE" November 18-19, 2024, Dubna University, Dubna, RF. (Oralreport).
33. MezentsevaZh.V., Doroshkevich A.S., Oksengendler B.L., Kirillov A.K., Didenko E.A., Nikiforova N.N., Mita Carmen, Mardare Diana, Cornei Nicoleta, Suleimanov S.H., Parpiev O.R. Electrical Properties of Interfaces of Hydrated Multi-Dimensional YSZ Nanopowders for Promising Applications of Renewable Energy and Homogeneous Electronics // Third International Forum "Physics - 2024", Samarkand State University and Institute of Engineering Physics Samarkand, Uzbekistan, April 23-25, 2024 (Poster).
34. Chepurchenko I.A., Doroshkevich A.S., Vishnevskiy S.V., Ledo Pereda L.M., Gremenok V.F., Teofilović Vesna, Erceg Tamara, Ristić Ivan. The electrostatic generator EG-5: possibilities in nuclear physics and methods of surface non-destructive experimental research. IPEC-9, Arifov Institute of Ion-Plasma and Laser Technologies, Uzbekistan Academy of Sciences 3 to 4 October 2024 in Tashkent, Uzbekistan. ("Ninth International Conference on Physical Electronics IPEC-9", October 3-4, 2024, Tashkent). (Poster).
35. Yakimenko M.N., Sheveleva A.V., Belichko D.R., Volkova G.K., Maletskii A.V. Investigation of physical properties of ZrO□. IX International Scientific Conference "Donetsk Readings 2024: Education, Science, Innovations, Culture and Challenges of Modernity", October 15-17, 2024, Donetsk. (Poster).
36. Yakimenko M.N., Belichko D.R., Maletskii A.V. The role of formed inclusions in the structure of YSZ ceramics. In the collection of conference abstracts: International Scientific Conference of Students, Postgraduates and Young Scientists "Lomonosov-2024", Moscow, April 12-26, 2024. (Poster).

2025

1. Kruglyak A.I. XXV All-Russian Conference "Biotechnology in Plant Breeding, Animal Husbandry and Agricultural Microbiology" Conference of Young Scientists (Moscow, November 18-21, 2025, FGBNU VNIISB). Oralreport.
2. Kruglyak A.I. XXVI Interuniversity Youth Scientific School-Conference named after B.S. Ishkhanov "Concentrated Energy Fluxes in Space Technology, Electronics, Ecology and Medicine" November 26-27, 2025, Moscow, MSU, Russia. Oralreport.
3. Kruglyak A.I. IV International Youth Conference, Obninsk: NRC "Kurchatov Institute" – VNIIRAE, October 22–23, 2025. Oralreport.
4. Kruglyak A.I. V All-Russian Scientific-Practical Conference (with international participation). Dubna, State University "Dubna", November 24–27, 2025. Oralreport.
5. Kruglyak A.I. 8th International Scientific Conference "Plant Genetics, Genomics, Bioinformatics and Biotechnology" (PlantGen2025), July 2–5, 2025, ICiG SB RAS, Novosibirsk, Russia. Listener.
6. Ibrahim Mahmoud. Kazakh-British Technical University & Oil Engineering Institute "One Belt, One Road". (2025). International Scientific Conference «CollNanoIndustry 2025». Oralreport.
7. Ibrahim Mahmoud. Colloids and Nanotechnologies in Industry (CollNanoIndustry 2025) - Kazakh-British Technical University (KBTU). Oralreport.
8. Ibrahim Mahmoud. Institute of Nuclear Physics and Joint Institute for Nuclear Research. III International School-Conference "Atom. Science. Technology." Almaty, Kazakhstan, April 16–18, 2025. Oralreport.
9. Ibrahim Mahmoud. International School on Complex Systems and Prospective Materials, Joint Institute for Nuclear Research (JINR) | Dubna, Russia - July 2025. Oralreport.
10. Ibrahim Mahmoud. (XV All-Russian Scientific Conference with International Participation 'Chemical Thermodynamics and Kinetics'). May 19, 2025, Donetsk. Poster.
11. Ibrahim Mahmoud. (XXI All-Russian Symposium with International Participation 'Physico-Chemical Problems of Adsorption, Structure and Surface Chemistry of Nanoporous Materials'). April 22-25, 2025, Moscow, Russia. Oralreport.

2026

1. Mahmoud Ibrahim, ZhannaMezentseva, Alexander Doroshkevich. Quantum Diode-Like Behavior in Hydrated ZrO□ Nanopowder Junctions under Radiation Flux and Humidity Control. / Program and Book of Abstracts of the 3rd International Conference on Innovative Materials in Extreme Conditions (IMEC2026), 25-27 March 2026 Belgrade, Serbia P43. ISBN 978-86-7306-181-8.
2. Anthony Carlos Perez Moreno. Electrical impedance analysis of a ZrO□-based nanopowder system on extreme ionization conditions / Program and Book of Abstracts of the 3rd International Conference on Innovative Materials in Extreme Conditions (IMEC2026), 25-27 March 2026 Belgrade, Serbia P.44. ISBN 978-86-7306-181-8.
3. Silvia Fortuné-Fábregas, Samir Samedov, Oleg Orlov, Alexey Sidorin, Augusto Iribarren, Lídice Vaillant-Roca and Alexander S. Doroshkevich. Defect dynamics and structural evolution of CuO nanostructures under extreme fluence of He^+ ions irradiation / Program and Book of Abstracts of the 3rd International Conference on Innovative Materials in Extreme Conditions (IMEC2026), 25-27 March 2026 Belgrade, Serbia. P46. ISBN 978-86-7306-181-8.

2.2.7. Patent Activity

1. Utility Model Patent No. 229847 Russian Federation, Federal Service for Intellectual Property H01L 31/0256 (2024.08); B82B 1/10 (2024.08); B82Y 40/00 (2024.08) — Combined humidity and illumination sensor based on nanoporous perovskite crystals; Didenko Ekaterina Alekseevna, SamedovaUlker Farrukh kyzy, Doroshkevich Alexander Sergeevich, MezentsevaZhanna Vladimirovna, Zelenyak Tatyana Yuryevna, Novikova SagilaAladdinovna. Patentowner: Dubna University.

2.4. Results of related activities

2.4.1. Research and education activities. List of defended dissertations.

Full list of PhD students 2024-2026

1. Rafael Isaev (, NRNU MEPhI, Moscow, Junior Researcher, FLNP);
2. Anastasiya I. Kruglyak (, VNIISB, Moscow, Engineer, FLNP).
3. Anthony Carlos Perez Moreno (, Voronezh State University, Intern-Researcher, FLNP)
4. Silvia Fortune (University of Havana, Havana, Cuba);
5. Ibrahim Mahmoud Ahmed Mostafa Ahmed (, Tomsk Polytechnic University (TPU), Intern-Researcher, FLNP)
6. AltynAltynbassova (Karaganda Industrial University, Republic of Kazakhstan, Intern-Researcher)
7. Aradeib Ayman Omer Ali (Intern-Researcher, FLNP, Master's student, NRNU MEPhI, Moscow.)

Number of students performing graduation thesis work or internship based at the department: - 21 (State Budgetary Educational Institution of Higher Education "Dubna University", Faculty of Natural and Engineering Sciences, Department of Chemistry, New Technologies and Materials).

2024

1. Ekaterina A. Didenko (4th year);
2. Polina A. Rumyantseva (1st year);
3. Karina I. Malkova (1st year);

4. Dilnoza R. Rashidova (1st year);
5. Mekhrinisa M. Khosinova (1st year);
6. Elena A. Kibardina (2nd year);

2025

1. Elena A. Kibardina (3th year);
2. Polina A. Rumyantseva (2nd year);
3. Karina I. Malkova (2nd year);
4. Dilnoza R. Rashidova (2nd year);
5. Mekhrinisa M. Khosinova (2nd year);
6. Victoria Novakovskaya (1st year);
7. AnastasiaTarasova (1st year);
8. Alexander Stepashkin (1st year);
9. Tatarinova A.A. Kant Baltic Federal University, Kaliningrad (1st year Master student)

2026

1. Elena A. Kibardina (4th year);
2. Karina I. Malkova (2nd year);
3. Victoria Novakovskaya (2stYear);
4. AnastasiaTarasova (2stYear);
5. Alexander Stepashkin (2stYear);
6. Tatarinova A.A. Kant Baltic Federal University, Kaliningrad (2st year Master student)

Practice UC JINR program:

1. Jeannine Milanés, Mexico Western Institute of Technology and Higher Education to participate. (START, 2025).

2.4.2. JINR grants (scholarships) received.

1. Project, Belarus - JINR - 2024; Order № :289, from 05.04.2024 pp.16, 17, 18, (BSU «Institute of nuclear problems», «Institute of nuclear problems», Minsk, Republic of Belarus; BSU ;
2. Project, Belarus - JINR - 2024; Order № 130 from 13.02.2024, pp.16, 17, 18, (BSU «Institute of nuclear problems», «Institute of nuclear problems», Minsk, Republic of Belarus; BSU ;
3. Project, JINR – Serbia 2024 Order №51 from 24.01.2024, pp.4,5 Laboratory of Physics, INN Vinča (Belgrade), University of Novi Sad (Novi Sad), Serbia.
4. Project, JINR – Serbia 2024 Order №50 from 24.01.2024, pp.7,8 Laboratory of Physics, INN Vinča (Belgrade), University of Novi Sad (Novi Sad), Serbia.
5. Order No. 676 of August 4, 2025, paragraph 7, "Application and Development of Particle Beam Analysis Methods in Archaeometry and Materials Science."
6. JINR – Republic of Serbia Cooperation Program for 2025. Order No. 38 of January 23, 2025, paragraph 8, "Application and Development of Particle Beam Analysis Methods in Archaeometry and Materials Science."
7. JINR – Republic of Belarus Cooperation Program for 2025. Order No. 234 of March 21, 2025, paragraph 19. "Modification of the Structure and Electrical Properties of Tin Oxide Films by Light Gas Ion Implantation for Sensor Applications ("Modification of Tin Oxide Films")."
8. JINR – Republic of Belarus Cooperation Program for 2025. Order No. 32 of January 23, 2025, paragraph 15. "The Effect of Helium Implantation on the Sensory Properties of Disordered Tin Oxide Films (Tin Oxide Films)."
9. JINR – Republic of Belarus Cooperation Program for 2025. Order No. 32 of January 23, 2025, paragraph 16. "The Effect of Light Gas Ion Implantation on Magnetic Field Transport Processes in Granular Structures Based on Strontium Ferromolybdate (The Effect of Implantation on Electrotransport)." 10. JINR – Republic of Belarus Cooperation Program for 2025. Order No. 32 of January 23, 2025, paragraph 17. "Study of the Effect of Light Gas Ion Implantation on the Crystal Structure and Electrical Characteristics of Cu2CdCe1-xSnxSe4 Solid Solution Semiconductor Materials ("Implantation and Solid Solutions")."

10. JINR – Republic of Kazakhstan Cooperation Program for 2025. Order No. 351 of April 24, 2025, paragraph 15. "Study of the Corrosion and Radiation Resistance of Ceramic Materials on the Surface of Zirconium Alloys for Use in Water-Cooled Nuclear Reactors."
11. 12. JINR – Republic of Serbia Cooperation Program for 2025. Order No. 38 of 23.01.2025, paragraph 8. Project title: "Application and Development of Particle Beam Analysis Methods in Archaeometry and Materials Science."
12. JINR – Republic of Serbia Cooperation Program for 2026. Order No. 109 of 03.02.2026, paragraph 9. "Application and Development of Particle Beam Analysis Methods in Archaeometry and Materials Science."
13. JINR – Republic of Belarus Cooperation Program for 2026. Order No. 302 of 01.04.2026. Item 18. "Radiation-stimulated changes in the structure, electrical conductivity, and humidity sensitivity of tin oxide films induced by helium and hydrogen ions (Modification of tin oxide films 2026)."
14. JINR – Arab Republic of Egypt Cooperation Program in 2026. Order No. 127 of 09.02.2026. Item 8. "Micropixel nanopowder position-sensitive radiation detector technology with eco-engineered materials for sustainable sensing".
15. JINR – Republic of Kazakhstan Cooperation Program in 2026. Order No. 111 of 03.02.2026. Item 13. "Study of the corrosion and radiation resistance of ceramic materials on the surface of zirconium alloys for use in water-cooled nuclear reactors".

2.4.3. Awards and prizes.

1. Alexander Maletsky. First place in the Semiconductor Physics and Technology section on the topic “Electrochemical Impedance Spectroscopy of Planar Chemo-Electronic Energy Converters Based on YSZ Nanopowders” at the 2024 IEEE 25th International Conference of Young Professionals in Electron Devices and Materials (EDM), June 28 – July 2, 2024, Altai, Russia



2. Didenko E.A. 2nd place in the section "Advanced materials, nanomaterials and technologies for their production" II All-Russian conference with international participation "Modern methods of obtaining materials and surface treatment and coating application - 2024".



II Всероссийская конференция с международным участием
«Современные методы получения материалов, обработки поверхности и нанесения покрытий»

ДИПЛОМ ПОБЕДИТЕЛЯ

II место
в секции «Перспективные материалы, наноматериалы и технологии их производства»

Диденко Екатерина Алексеевна,
студент ФГБОУ ВО «Университет «Дубна»,

с научной работой
«Электрические характеристики твердых растворов типа MeSe-$CuInSe_2$ (Me=Mn, Fe) в зависимости от атмосферной влажности»

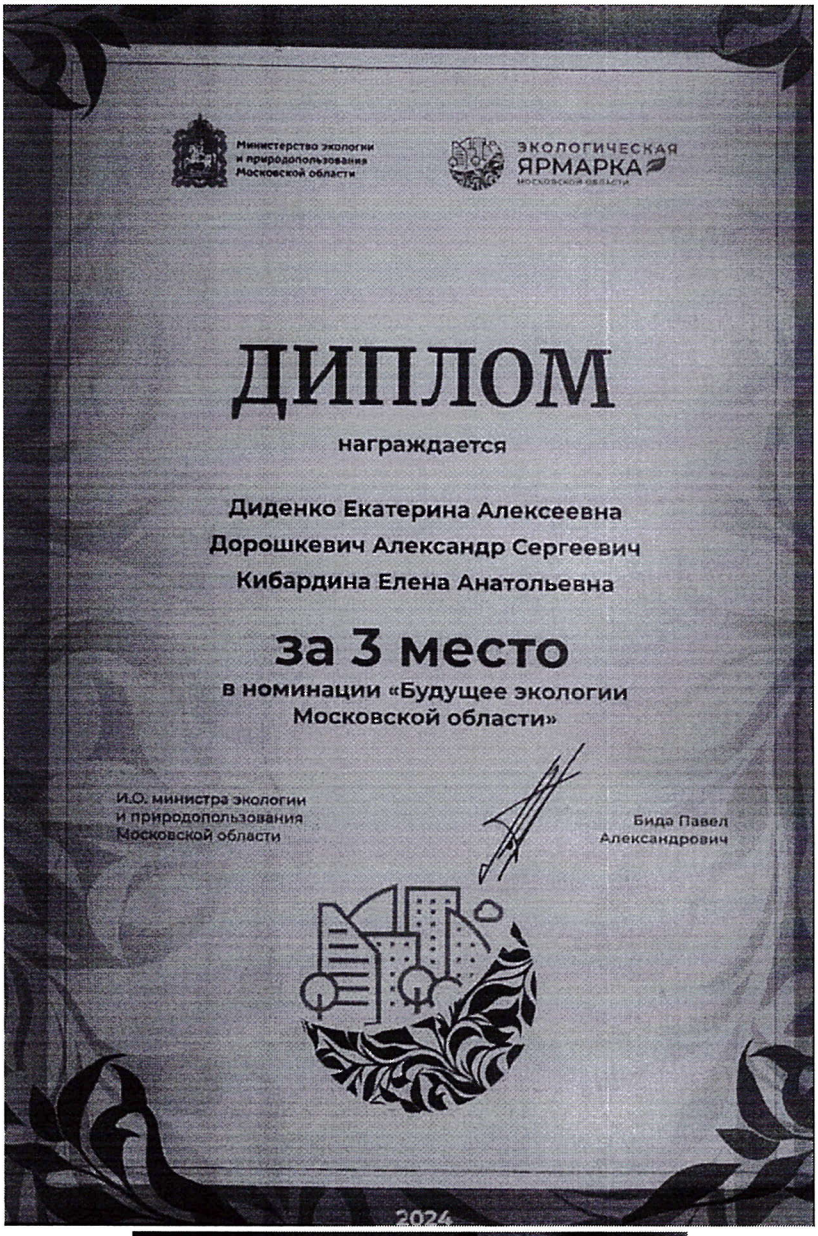
Научный руководитель:
к.ф.-м.н., начальник группы
Дорошкевич Александр Сергеевич
Объединенный институт ядерных исследований,
Лаборатория Нейтронной Физики

Председатель,
д.т.н., профессор
ФГБОУ ВО «КНИТУ»
Рахматуллина Г.Р.

29 марта 2024 года

Материаловедение
Казань

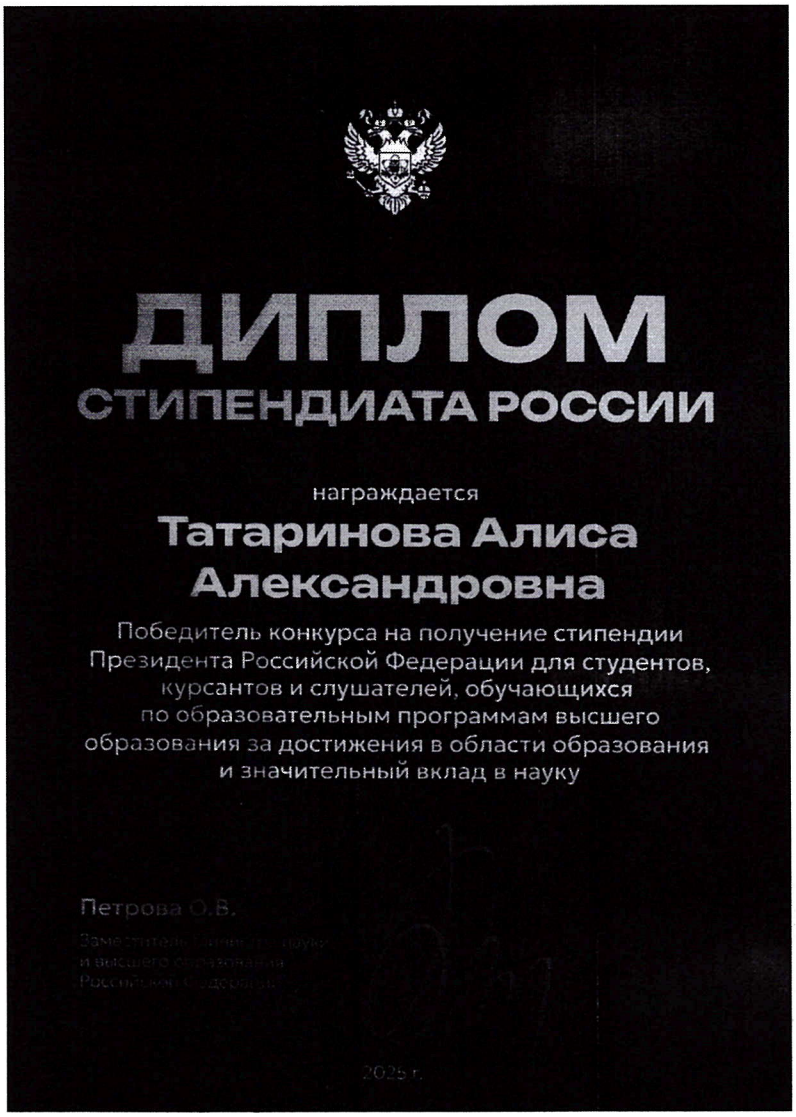
3 Didenko E.A. 2nd place at the event "Ecological Fair of the Moscow Region - 2024"





2025

1. Tatarinova A.A. Scholarship of the President of the Russian Federation, "Mathematical and Natural Sciences" 2025/26 (https://kantiana.ru/news/pozdravlyaem-studentov-bfu-im-i-kanta-laureatov-prestizhnykh-stipendiy-prezidenta-i-pravitelstva-rf/#).



ДИПЛОМ
СТИПЕНДИАТА РОССИИ

награждается
Татаринова Алиса
Александровна

Победитель конкурса на получение стипендии
Президента Российской Федерации для студентов,
курсантов и слушателей, обучающихся
по образовательным программам высшего
образования за достижения в области образования
и значительный вклад в науку

Петрова О.В.

2025 г.

2. Kruglyak A.I., AlekseenokYu.V., Volkova P.Yu., Doroshkevich A.S., Soloviev A.A. Estimation of the threshold dose of fast neutron irradiation for inducing an adaptive response in triticale seedlings (xTriticosecale). "Biotechnology in crop production, animal husbandry and agricultural microbiology": XXV All-Russian Conference "Biotechnology in crop production, animal husbandry and agricultural microbiology" conference of young scientists (Moscow, November 18-21, 2025, FGBNU VNIISB. Third-degree diploma for the best report.

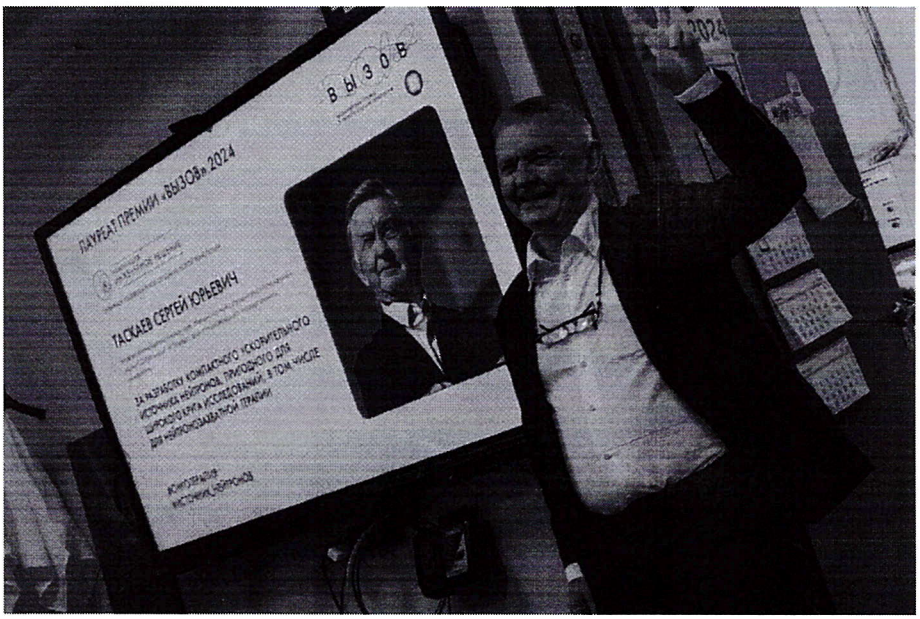

ФГБНУ ВНИИСБ

ДИПЛОМ
III степени

За лучший доклад в секции
«Клеточные биотехнологии, регуляторы роста и развития растений»
присуждается
Кругляк Анастасии Игоревне
ЗАЛОЖЯЯ
Оценка пороговой дозы облучения быстрыми нейтронами для индукции адаптивного ответа у проростков тритикале (X Triticosecale)
в рамках XXV Всероссийской молодежной научной конференции
«Биотехнология в растениеводстве, животноводстве и сельскохозяйственной микробиологии»
г. Москва, 18 – 21 ноября 2025 г

Директор
академик РАН
_____ Г.И. Карлов

3. Taskaev S. Yu. National Prize in the field of future technologies "Challenge" in the nomination "Engineering solution"

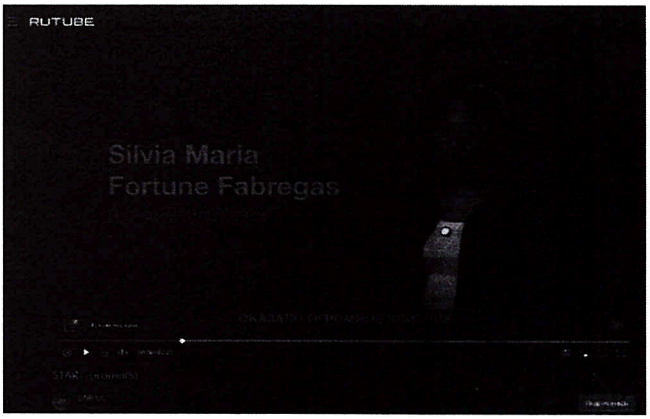


2.4.4. Other results (expert, scientific-organisational, scientific-propaganda activities).

1. Silvia María FortunéFábregas

Promotional video for the START Programme.

https://rutube.ru/video/private/2b00a97cbef222ff5b2c02c9c7e6f6a4/



2. Sergey Yuryevich Taskaev
Sergey Yuryevich Taskae, Rossiyskaya Gazeta - Federal Issue: No. 293 (9535)

3. Sergey Yuryevich Taskaev YouTube broadcast
https://www.youtube.com/watch?v=Z0KqxHQRW8U



Advanced Training
N.A. Kruglyak, Moscow Technological Institute, 2nd semester (1st year). Major: Control in Technical Systems. Specialization: Systems and Equipment for Automation of Technological Processes.

2.4.4. Other results (expert, scientific-organisational, scientific-propaganda activities) - no.

3. International scientific and technical cooperation.

During the project's implementation, collaboration has been established with research centers in Serbia, Belarus, Kazakhstan, and Egypt. A number of joint projects are underway within the framework of relevant programs (see Section 2.4.2. JINR Grants (Scholarships) Received).

As part of these projects under the JINR-Serbia program, joint work is being carried out in the fields of archaeometry (study of Serbia's cultural heritage) and powder nanotechnology (development of adsorption hydroelectric converters for advanced construction technologies and multifunctional coatings for isolated spaces). Through collaboration with Belarusian colleagues, semiconductor structures for advanced gas sensorics are being developed using accelerator technologies. As part of the JINR-Kazakhstan program project, the Sector is participating in the development of anticorrosive fuel rod coatings as part of the development of accident-tolerant nuclear fuel.

Actually participating countries, institutions and organisations

Organization	**Country**	**City**	**Participants**	**Type of Agreement**
Egyptian Atomic Energy Authority	Egypt	Cairo	Egypt: Mostafa Saleh, Hossam El-Din; JINR: Doroshkevich A.S.	Cooperation Agreement
The British University in Egypt (BUE)	Egypt	Cairo	Egypt: Salama Ahmed Elsaid; JINR: Doroshkevich A.S.	Cooperation Agreement

Institute of Nuclear Sciences, Ege University	Turkey	Izmir	Turkey: TanyildiziŞükrüHanife; JINR: Doroshkevich A.S.	Cooperation Agreement
"Polywood" Limited Liability Company	RF	Moscow	Moscow: Smolyansky Alexander Sergeevich; JINR: Doroshkevich A.S.	Cooperation Agreement
"Kvant-R" Limited Liability Company	RF	Moscow	Moscow: Smolyansky Alexander Sergeevich; JINR: Doroshkevich A.S.	Cooperation Agreement
National Museum ofSerbia	Serbia	Belgrade	Serbia: Milica MarićStojanović; JINR: Doroshkevich A.S.	Cooperation Agreement
BandırmaOnyediEylül University (BANU)	Turkey	Bandırma	Turkey: Büyük Bülent; JINR: Doroshkevich A.S.	Cooperation Agreement
Center for Research and Advanced Studies of the National Polytechnic Institute (Cinvestav)	Mexico	San PedroZacatenco	Mexico: Yuri Kudryavtsev; JINR: Doroshkevich A.S.	Cooperation Agreement
Rzhanov Institute of Semiconductor Physics SB RAS	RF	Novosibirsk	Novosibirsk: Timofeev Vyacheslav Alekseevich; JINR: Doroshkevich A.S.	Cooperation Agreement
IKBFU, REC "FunctionalNanomaterials"	RF	Kaliningrad	Kaliningrad: Shvets Petr Valerievich; JINR: Doroshkevich A.S.	Cooperation Agreement
P.N. Lebedev Physical Institute of the RAS	RF	Moscow	Moscow: Soshenko Vladimir Vladimirovich; JINR: Doroshkevich A.S.	Cooperation Agreement
"Russian Engineering School"	RF	Moscow	Moscow: Kibalnikov Sergey Vladimirovich; JINR: Doroshkevich A.S.	Cooperation Agreement
Institute ofPhysics, UNAM	Mexico	Coyoacán	Mexico: Chavez Lomeli Efrain Rafael; JINR: Doroshkevich A.S.	Cooperation Agreement
I. Zhakhayev Kazakh Research Institute of Rice Growing	Kazakhstan	Kyzylorda	Kazakhstan: TauipbaevSultanbekTauipbaevich; JINR: Doroshkevich A.S.	Cooperation Agreement
Luikov Heat and Mass Transfer Institute of the NASB	Belarus	Minsk	Belarus: Grinchuk Pavel Semenovich; JINR: Doroshkevich A.S.	Cooperation Agreement
National University of Science and Technology MISIS	RF	Moscow	Moscow: Lagov Petr Borisovich; JINR: Doroshkevich A.S.	Cooperation Agreement
Ural Federal University named after B.N. Yeltsin	RF	Yekaterinburg	Yekaterinburg: Zatsepin Anatoly Fedorovich; JINR: Doroshkevich A.S.	Cooperation Agreement
Institute of Materials Science SPA	Uzbekistan	Tashkent	Tashkent: Suleimanov Sultan Hamidovich; JINR:	Cooperation Agreement

"Physics-Sun"			Doroshkevich A.S.	
Dubna State University	RF	Dubna	University: Nemchenok Igor Borisovich; JINR: Doroshkevich A.S.	Cooperation Agreement
Institute of Radiation Problems (IRP MNOAR)	Azerbaijan	Baku	Azerbaijan: MirzaevMatlab Nabi oglu; JINR: Doroshkevich A.S.	Cooperation Agreement
Institute of General and Inorganic Chemistry of the NASB	Belarus	Minsk	Belarus: Ivanets Andrey Ivanovich; JINR: Doroshkevich A.S.	Cooperation Agreement
University ofHavana	Cuba	Havana	Cuba: Gonzalez Edwin Pedrero; JINR: Doroshkevich A.S.	Cooperation Agreement
All-Russian Research Institute of Forest Genetics	RF	Voronezh	Voronezh: Semenov Mikhail Alexandrovich; JINR: Doroshkevich A.S.	Cooperation Agreement
NJSC "Karaganda Industrial University"	Kazakhstan	Temirtau	Kazakhstan: AinabekovaSauleSerikbaevna; JINR: Doroshkevich A.S.	Cooperation Agreement
L.M. Litvinenko Institute of Physical-Organic Chemistry	RF	Donetsk	Donetsk: Khomutova Ekaterina Valerievna; JINR: Doroshkevich A.S.	Cooperation Agreement
University of Novi Sad, Faculty of Technology	Serbia	NoviSad	Novi Sad: Vesna Teofilović; JINR: Doroshkevich A.S.	Cooperation Agreement
University of Belgrade, "Vinča" Institute	Serbia	Belgrade	Belgrade: Jovanović Zoran; JINR: Doroshkevich A.S.	Cooperation Agreement
KorkytAtaKyzylorda University	Kazakhstan	Kyzylorda	Kyzylorda: AppazovNurbolOrynbasaruly; JINR: Doroshkevich A.S.	Cooperation Agreement
Frumkin Institute of Physical Chemistry and Electrochemistry	RF	Moscow	Moscow: Tameev Alexey Raisovich; JINR: Doroshkevich A.S.	Cooperation Agreement
JSC "SNIIP"	RF	Moscow	Moscow: Tkachev Sergey Valerievich; JINR: Doroshkevich A.S.	Cooperation Agreement
JSC "Mikron"	RF	Moscow	Moscow: Shipiguzov Artur Vasilievich; JINR: Doroshkevich A.S.	Cooperation Agreement
JSC "Mikron"	RF	Moscow	Moscow: Vrenev Ya. V.; JINR: Doroshkevich A.S.	Waferprocessingcontract
JSC "Angstrem"	RF	Moscow	Moscow: GadzhievAsadulaAbdulmuslimovich; JINR: Doroshkevich A.S.	Cooperation Agreement
IMET RAS (Baikov	RF	Moscow	Moscow: Anokhin Alexander	Cooperation

Institute)			Sergeevich; JINR: Doroshkevich A.S.	Agreement
Donetsk Institute for Physics and Engineering (Galkin)	RF	Donetsk	Donetsk: ShalaevRostislavValerievich; JINR: Doroshkevich A.S.	Cooperation Agreement
Scientific-Practical Materials Research Centre NASB	Belarus	Minsk	Minsk: Gremenok Valery Felixovich; JINR: Doroshkevich A.S.	Cooperation Agreement
Immanuel Kant Baltic Federal University	RF	Kaliningrad	Kaliningrad: Rodionova Valeria Viktorovna; JINR: Doroshkevich A.S.	Cooperation Agreement

4. Plan/actual analysis of resources used: human (including associated personnel), financial, IT, infrastructure

4.1. Human resources (actual at the time of reporting, total number of participants)
(total number of participants)

№№ п/a	Categoryemployee	Core staff Amount of FTE	Associated personnel Amount of FTE
1.	Scientific employees	10,75	
2.	engineers	5,5	
3.	professionals	1	
4	employees	5,52	
5	workers		
	Total:	**22,77**	

4.2. The actual estimated cost of the project

Names of costs, resources, funding sources		Cost (thousands of dollars) resource requirements	Proposal from the laboratory for allocation of funding and resources				
			1st year	2nd year	3rd year		
	International cooperation (IC)	28,73	8,49	20,24	-		
	Materials	136,03	67,82	40,21	28		
	Equipment and third-party services	453,56	161,11	214.02	78,43		
	Commissioningwork						
	Services ofresearchorganisations	20			20		
	Acquisitionofsoftware	9,65	5	4,65			
	Design/construction				-		

		Service costs (*planned in case of direct project affiliation)*						
Resources required	**Normo-hours**							
		theamountofFTE,	134707	44902	44902	44902		
		accelerator/installation						
		reactor						
Sourcesoffunding	**Budgetaryresources**		647.97	242,42	279,12	126,43		
	Extrabudgetary (supplementaryestimates)	Contributions by co-contractors Funds under contracts with customers Other sources of funding						

4.3.Other resources – no

5. Conclusion

As a result of the project, a unique electrostatic accelerator at JINR will be modernized and commissioned, enabling the solution of a number of problems in nuclear and neutron physics and radiation materials science.

6. Proposed Reviewers

1. Petr BorisovichLagov, Doctor of Engineering, Professor, Department of Semiconductor Electronics and Semiconductor Physics, NUST MISIS, Moscow, Russian Federation. E-mail: lagov2000@mail.ru.

2. Walter Ilyich Furman, Doctor of Physics and Mathematics, Leading Researcher, Laboratory of Neutron Physics, JINR, Dubna, Moscow Region, Russian Federation. E-mail: furman@nf.jinr.ru,

3. Valery Viktorovich Nesvizhevsky, Doctor of Physical and Mathematical Sciences, Institut Laue-Langevin, Grenoble, E-mail: nesvizhevsky@ill.fr, nesvizhevsky@ill.eu

Theme Leader

_____/_____/

"04" мая 2026

Project Leader

_____/Доронин/

"04" мая 2026

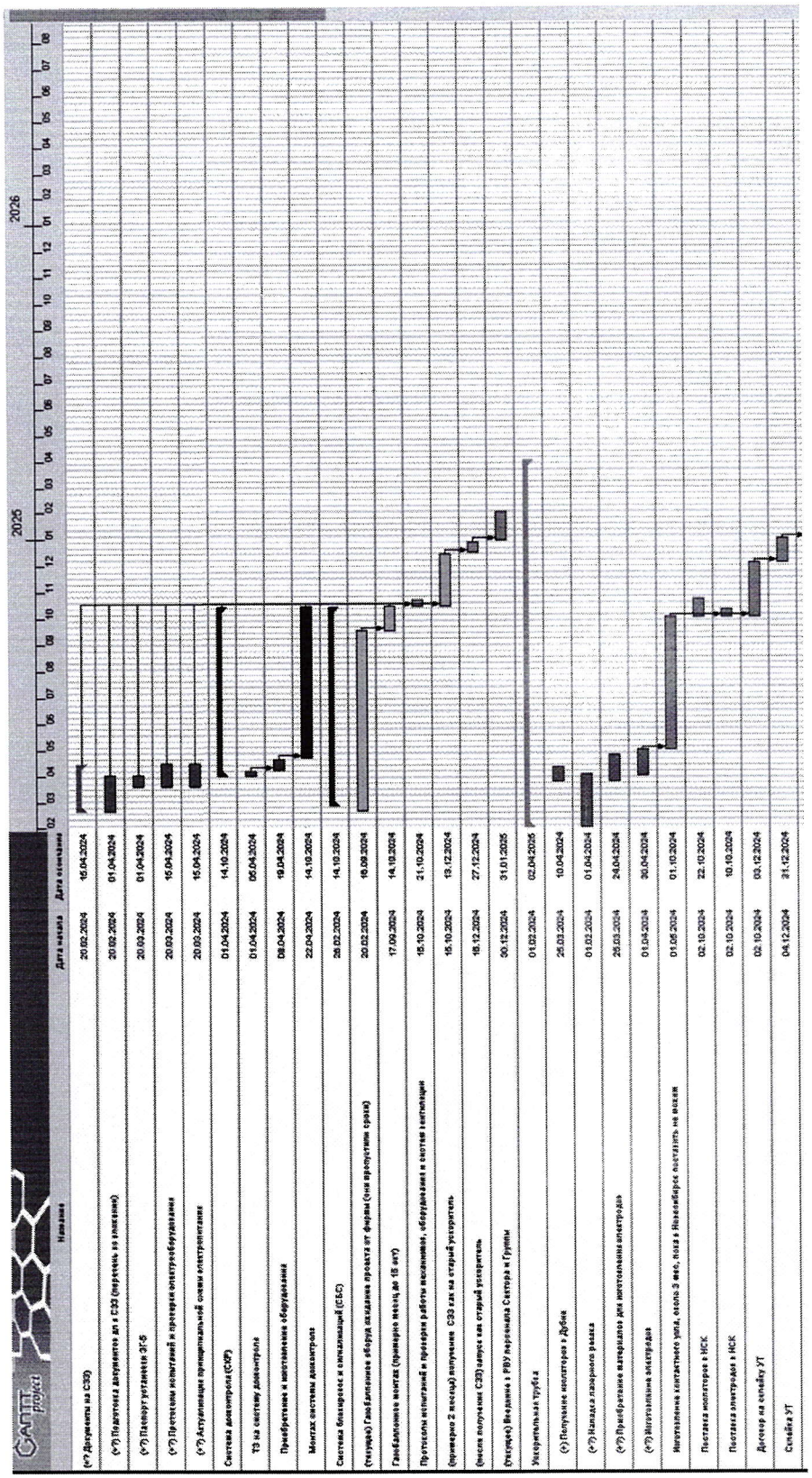
Laboratory Economist

_____/Сорокина/

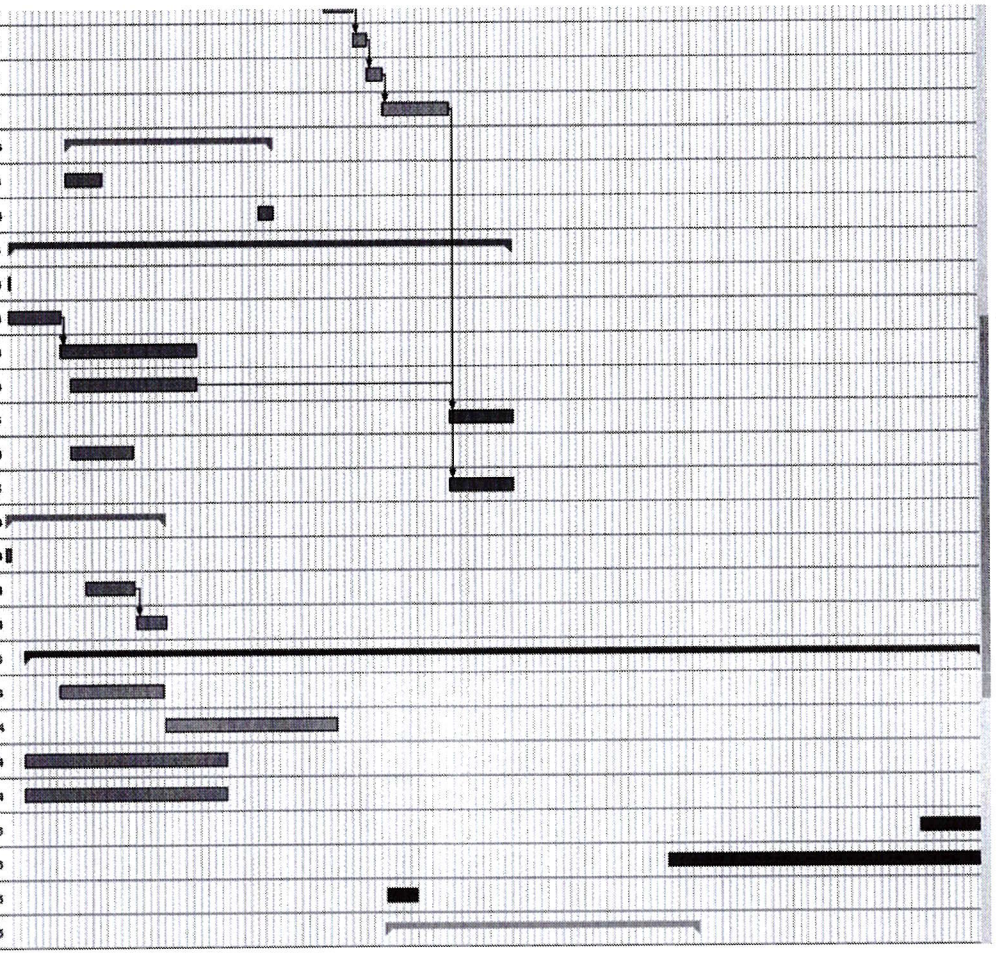
"04" мая 2026

Appendix 5.

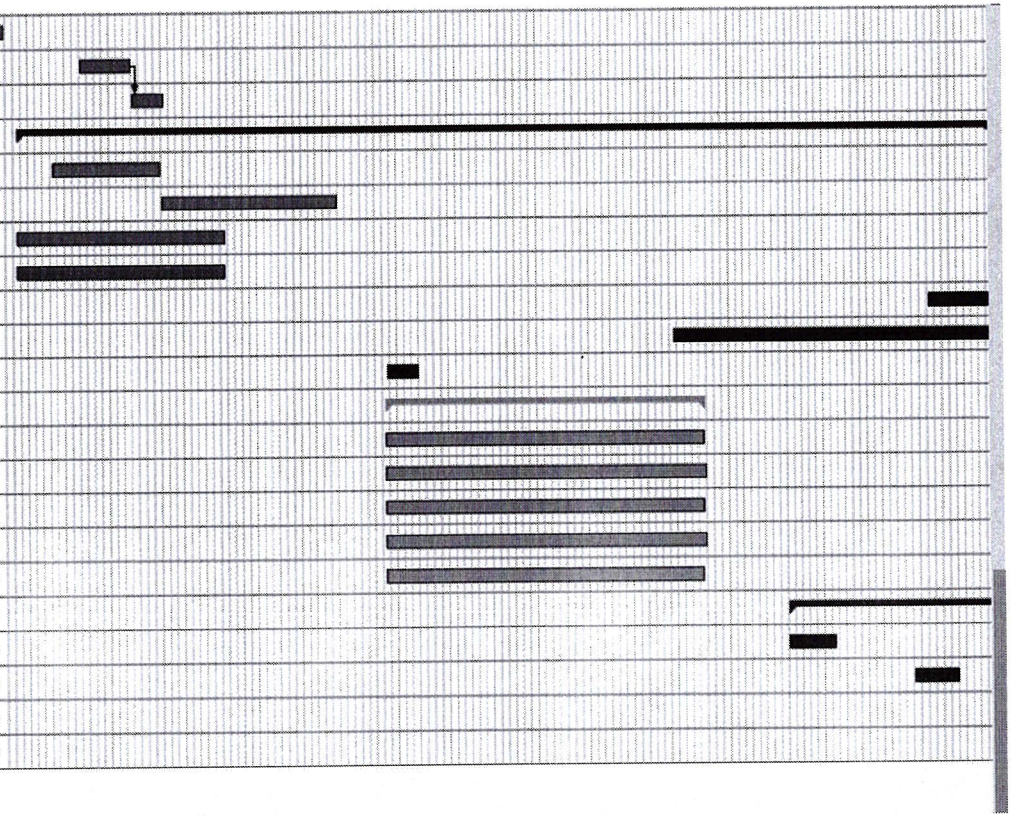
Plan and schedule for the period February 20, 2024 – December 31, 2026



Контроль качества сплайна в НСК	01.01.2025	13.01.2025
Поставка УТ в Дубну	14.01.2025	28.01.2025
Монтаж трубки в ускоритель	29.01.2025	02.04.2025
(+?) Резисторный делитель напряжения	27.03.2024	14.10.2024
(+?) Закупка резисторов делителя	27.03.2024	30.04.2024
(+?) Отладка новой ионно-оптической системы ЭГ-5	01.10.2024	14.10.2024
Ионный источник (готов?)	01.02.2024	02.06.2025
(+?) Поставка ИИ	01.02.2024	01.02.2024
(+?) Договор на изготовление СУ ИИ	01.02.2024	21.03.2024
(+?) Система управления ИИ	22.03.2024	31.07.2024
(+?) Проект размещения ИИ в подсводчатом пространстве	01.04.2024	31.07.2024
Монтаж ИИ	03.04.2025	02.06.2025
(+?) Договор на изготовление системы для ускорения Эк тяжелых газов	01.04.2024	30.06.2024
Монтаж системы ускорения тяжелых газов	03.04.2025	02.06.2025
(+?) Газокомпрессорное хозяйство	29.01.2024	01.07.2024
(+?) Проект модернизации ПХ	29.01.2024	01.02.2024
(+?) Монтаж	15.04.2024	31.05.2024
(+?) Техническое освидетельствование	03.06.2024	01.07.2024
Модернизация инфраструктуры ускорительного комплекса	15.02.2024	29.09.2026
Закупка источника питания аналитического магнита	20.03.2024	29.06.2024
Автоматизация системы разворота и проводки ионного пучка	01.07.2024	13.12.2024
(+?) Установка Li – напыление, подключение энергетического диапазона (н) 20 кэВ – 1МэВ	15.02.2024	29.08.2024
(+?) Модернизация ИЛА (RBS – камеры): перенос ТМН вакуумного н...	15.02.2024	29.08.2024
Отладка и запуск модуля канализования	30.06.2026	29.09.2026
Запуск FNNA метода в левом зале	30.10.2025	29.09.2026
Модернизация модуля ионной имплантации (экспериментального)	31.01.2025	28.02.2025
Правый зал	29.01.2025	29.11.2025



(+?) Проект модернизации ПКК	29.01.2024	01.02.2024
(+?) Монтаж	15.04.2024	31.05.2024
(+?) Техническое освидетельствование	03.06.2024	01.07.2024
Модернизация инфраструктуры ускорительного комплекса	15.02.2024	28.08.2026
Закупка источника питания аналитического магнита	20.03.2024	28.06.2024
Автоматизация системы разворота и проводки ионного пучка	01.07.2024	13.12.2024
(+?) Установка Li – мишени, подключение энергетического диапазона (в) 20 кэВ – 1МэВ	15.02.2024	28.08.2024
(+?) Модернизация ИПА (RBS – камеры): перенос ТМН вакуумного н...	15.02.2024	28.08.2024
Отладка и запуск модуля канализования	30.06.2026	28.08.2026
Запуск FNNA метода в левом зале	30.10.2025	28.08.2026
Модернизация модуля ионной имплантации (экспериментального)	31.01.2025	28.02.2025
Правый зал	29.01.2025	28.11.2025
Установка виброзащитного фундамента в правом зале под микропучковый спектрометр	29.01.2025	28.11.2025
Проект вентиляции / спецвентиляции в правом зале	29.01.2025	28.11.2025
Монтаж вентиляции в правом зале	29.01.2025	28.11.2025
Получение сертификата СЭЗ для ЭГ-5 и правого зала	29.01.2025	28.11.2025
Косметический ремонт Правого зала	29.01.2025	28.11.2025
Микропучковый спектрометр	16.02.2026	30.12.2026
Подготовка договора на закупку квадрупольной линзы для микропу...	16.02.2026	31.03.2026
Поставка квадрупольной линзы для микропучкового спектрометра	15.06.2026	24.07.2026
Монтаж микропучкового спектрометра	31.08.2026	13.11.2026
Физический пуск и отладка микропучкового спектрометра	16.11.2026	30.12.2026



Appendix 6.

Schedule of activities for resuming operation of the EG-5 power plant.

Утверждаю
Директор ЛНФ

_____ /Е.В.Лычагин

14.05 2025г

Согласовано
Главный инженер ЛНФ

_____ А.В.Виноградов

14.05 2025г.

План-график модернизации технологических систем ЭГ-5 с целью возобновления эксплуатации

№	Мероприятие	Срок исполнения	Ответственный
1.	Подача документов в ФМБА для получения заключения санитарно-эпидемиологической службы	31.05.2025	К.В.Удовиченко
2.	Демонтаж старого компрессора, подбор и закупка нового компрессора, разработка чертежей и схем подключения нового оборудования, физическое подключение нового компрессора к системе ГБО ЭГ-5, обновление принципиальной схемы ГБО ЭГ-5.	01.07.2025	И.А.Чепурченко
3.	Обучение персонала работе с компрессорным оборудованием, аттестация, получение удостоверений.	15.07.2025	И.А.Чепурченко
4.	Замена и согласование понижающего редуктора и предохранительных клапанов системы ГБО: подбор оборудования, обеспечение и согласование разрешительных документов, разработка чертежей и схем подключения, подключение оборудования	01.07.2025	И.А.Чепурченко
5.	Освидетельствование существующего электрооборудования совместно с ЭТО: создание списка необходимой документации на электрооборудование для установки ЭГ-5; обновление (создание) документации по существующим нормам и правилам; протоколы испытания электрооборудования	15.07.2025	А.Н.Лихачев
6.	Освидетельствование ГБО. Разрешение на работу газокомпрессорной установки: поверка манометров, акты испытания редукторов и клапанов; освидетельствование сосуда (котёл ЭГ-5), баллонов (18шт.), осушительной батареи (производитель работ ООО «Промышленная экспертиза»); обновление документации и инструкций; оформление разрешения на работу	15.08.2025	А.Н.Лихачев
7.	Ввод в эксплуатацию системы радиационного контроля ЭГ-5	31.10.2025г.	К.В. Удовиченко
8.	Ввод в эксплуатацию системы блокировок ЭГ-5	31.10.2025г.	А.С. Каюков
9.	Комиссионная приемка АСРК и СБиС	Ноябрь 2025г.	К.В. Удовиченко

№	Мероприятие	Срок исполнения	Ответственный
10.	Получение заключения санитарно-эпидемиологической службы	Ноябрь 2025г.	К.В. Удовиченко
11.	Комиссионное решение о возобновлении эксплуатации ЭГ-5	До конца 2025 года	А.С.Дорошкевич

Согласовано:

Заместитель директора Ю.Н.Копач

Начальник ОЯФ В.Н. Швецов

Начальник СЯФМИН ОЯФ А.С. Дорошкевич

Нач. группы СЯФМИН ОЯФ И.А. Чепурченко

Ведущий инженер СИНЯВ ОЯФ А.Н. Лихачёв

Начальник службы по монтажу, наладке и ремонту установки ИРЕН А.С.Каюков

Начальник службы управления установки «ИРЕН» К.В. Удовиченко

Appendix 7

Plan for the use of premises in building 120 by Sector of Nuclear Physics Materials Science and Ion-Implantation Nanotechnologies

The laboratory planned for placement in Building 120 will be a multifunctional, universal engineering and research complex designed to meet the needs of the SNPN in technological operations and materials science research methods. It aims to conduct research in the fields of nuclear-physical materials science, radiobiology, and ion-implantation nanotechnologies.

The complexincludes:

A chemical-biological laboratory (rms. 216, 217, 237), a research module (rms. 136, 119, 130), and an engineering module (rms. 119, 116, 123).

The laboratory will enable the fabrication of components required for nuclear-physical and nanotechnological research from a wide range of materials under laboratory conditions, including:

Objects of research: powder compacts, oxide ceramics, polished surfaces for RBS, samples of required sizes and shapes from hard and superhard materials, thin films (metal, semiconductor, magnetron coatings), thick films, semiconductor and nanopowder functional coatings and structures, objects for electron microscopy (vacuum degassing, brittle fracture in liquid nitrogen, single- and double-stage replicas, carbon vacuum contrast enhancement, magnetron gold contrast enhancement of fractures, cryogenic drying and vacuum polymer impregnation of biological tissues and porous objects, electrochemical etching of metals), biological objects (neutron-modified cereal sprouts), and others.

Experimental equipment: holders, dies, complex-shaped plastic parts, simple metal parts, housings, rubber seals, prototypes of electronic devices, quartz and ceramic products, masks and templates for vacuum deposition, etc.

Laboratory prototypes of functional structures based on nanopowders: adsorption hydroelectric converters, homogeneous electronics devices, neutron detectors, etc.; and structures based on semiconductor and perovskite systems (linear and matrix X-ray medical – detectors with reduced dose load).

Physical and chemical preparation of objects for experiments: hydration, dehydration, vacuum and thermal-vacuum degassing, preparation of chemical reagents and solutions, oxidation, chemical and ion etching, etc.

Research into radiation-induced effects in materials: structure (XRD), microstructure (STEM, Optical microscopy, SAXS), electronic structure (I-V, UV-spectrometer), electrical properties (I-V, EIS), and optical properties (Ellipsometry).

With the EG-5 electrostatic accelerator, the laboratory forms a unique research and technological complex, allowing for rapid research into the effects of a wide range of radiation fields on the structure and microstructure of materials, as well as technological development. The unified (within FLNP) localization of radiation structural modification methods and structural research methods will allow for the full realization of the research cycle at FLNP: **radiation impact – structure – properties**. The efficiency of the research work will also allow for:

Solving scientific and technological problems that require a multi-iterative approach.

In the field of powder nanotechnologies, the laboratory will enable a cycle of research into radiation effects in complex systems. This includes the modification of the electronic structure of hydrated/deuterated nanoscale ionic crystals using available radiation impacts (H^+ , He^+ , neutrons) to obtain new fundamental knowledge and functional materials for advanced specialized equipment. This specifically includes nanopixel position-sensitive detectors of neutron fields and homogeneous nanoelectronics devices capable of operating in intense neutron fields.

In addition to the SNPN's scientific and technological tasks, the laboratory will host internships under the Summer Student Internship program, as well as student coursework and graduation thesis projects.

1. Engineering Module (rms. 119, 116, 123, 216, 237)

Tasks:

1. Fabrication of samples for research using ion-beam analysis (IBA) methods, other nuclear-physical experiments, and nanotechnological experiments from customer materials;
2. Fabrication of functional structures from nanopowders and semiconductor films;

3. Fabrication of experimental prototypes of nanotechnological and other devices;
4. Fabrication of auxiliary devices and modules for nuclear-physical and nanotechnological experiments.

Equipment (rooms shown in Fig. 1, 4, 5, 6, 7, 9):

1. Workbench for mechanical assembly, assembly tools (vices, hand tools, electric hand tools (angle grinder, drill, etc.)) (rm. 119);
2. Radio assembly station (soldering iron, etc.) (rm. 119);
3. Fume hood for working with nanopowder objects (chemically clean, stainless steel) (rm. 118);
4. Fume hood for other works (non-chemical);
5. Airbrushes complete with compressor/argon cylinder and a heating plate for obtaining thick films by the spray pyrolysis method (rm. 217);
6. Equipment for obtaining nanofibers and porous nanostructured objects by the electrospinning method (rm. 234);
7. Centrifuge for obtaining thin-film semiconductor and nanopowder structures by the spin-coating method (rm. 216);
8. Vacuum system for magnetron sputtering of thin films (rm. 119);
9. Vacuum system for thermal evaporation of metals and carbon (for STEM) (rm. 136);
10. Ultrasonic humidifier for powders, compacts, and adsorption functional structures;
11. Ultrasonic nebulizer for obtaining thin films by depositing a polymer suspension from ultrasonic mist (rm. 234);
12. Glovebox (rm. 234);
13. Grinder (coffee mill type) (rm. 119);
14. Planetaryballmill (rm. 119);
15. Drying ovens - 3 units (for different types of objects) (rm. 119);
16. Vacuumdryingoven (rm. 216);
17. Manual press (10t) for pellet forming / Tensile testing machine (2t) (rm. 118);
18. 100t press for hydrostatic / quasi-hydrostatic compaction of compacts (rm. 118);
19. Muffle furnace with a maximum temperature of 500 °C, working volume 50 L (rm. 116);
20. Muffle furnace with a maximum temperature of 1300 °C, working volume 5 L for "dirty" work (rm. 116);
21. Muffle furnace with a maximum temperature of 1300 °C, working volume 2 L "clean" (rm. 237);
22. Laser weldingsystem (rm. 119);
23. Microhardnesstester (rm. 119);
24. Laser cuttingsystem (rm. 115);
25. Polishingmachine (rm. 123);
26. Grindingmachine (rm. 123);
27. Mini-cutting machine for preparing STEM samples (rm. 116);
28. Wire electrical discharge machine (EDM) for cutting superhard materials and preparing defect-free cuts for STEM (rm. 136);
29. Tubular muffle furnaces (1300 °C), diameters 80 mm and 20 mm, for annealing/synthesis of powders in an inert atmosphere and erosion testing of materials in a steam environment (rm. 237);
30. Lathe (rm. 115);
31. 3D printer (rm. 119);
32. Weldingmachine (rm. 116).

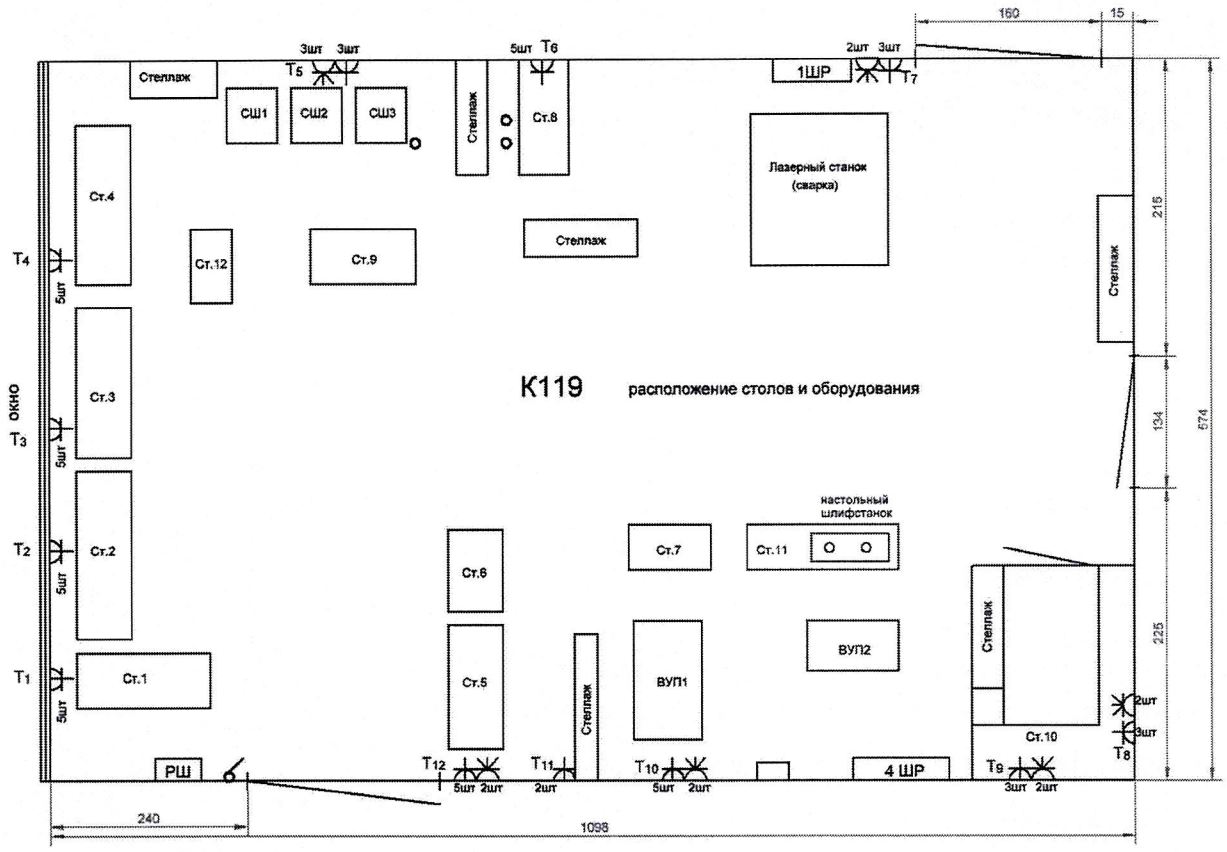


Fig. 1. Engineering module plan (to 119).

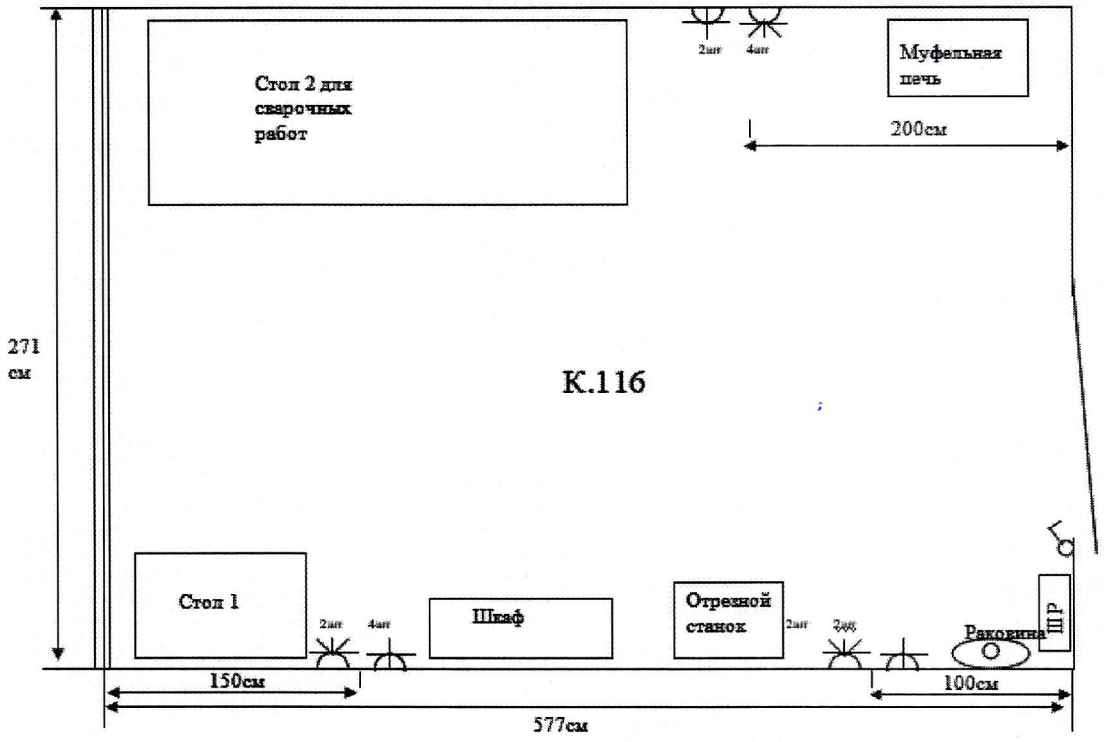


Fig. 6. Workshop plan for high-temperature work with samples.

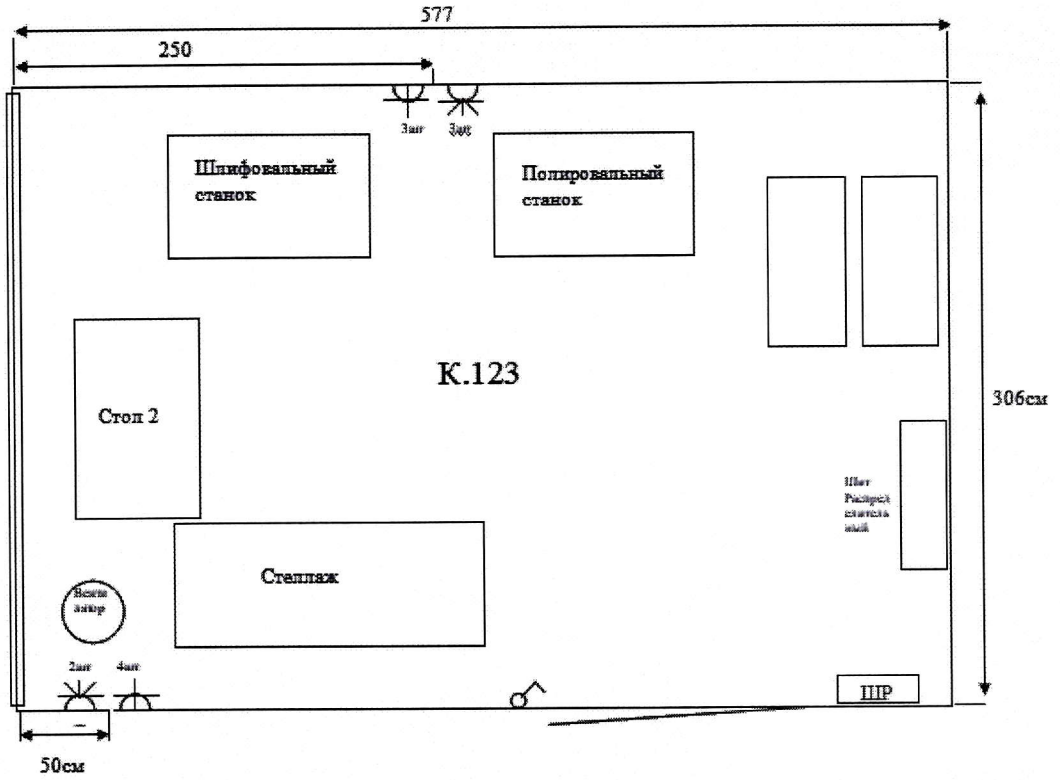


Fig. 7. Workshop plan for mechanical preparation of experimental samples (cutting, grinding, polishing).

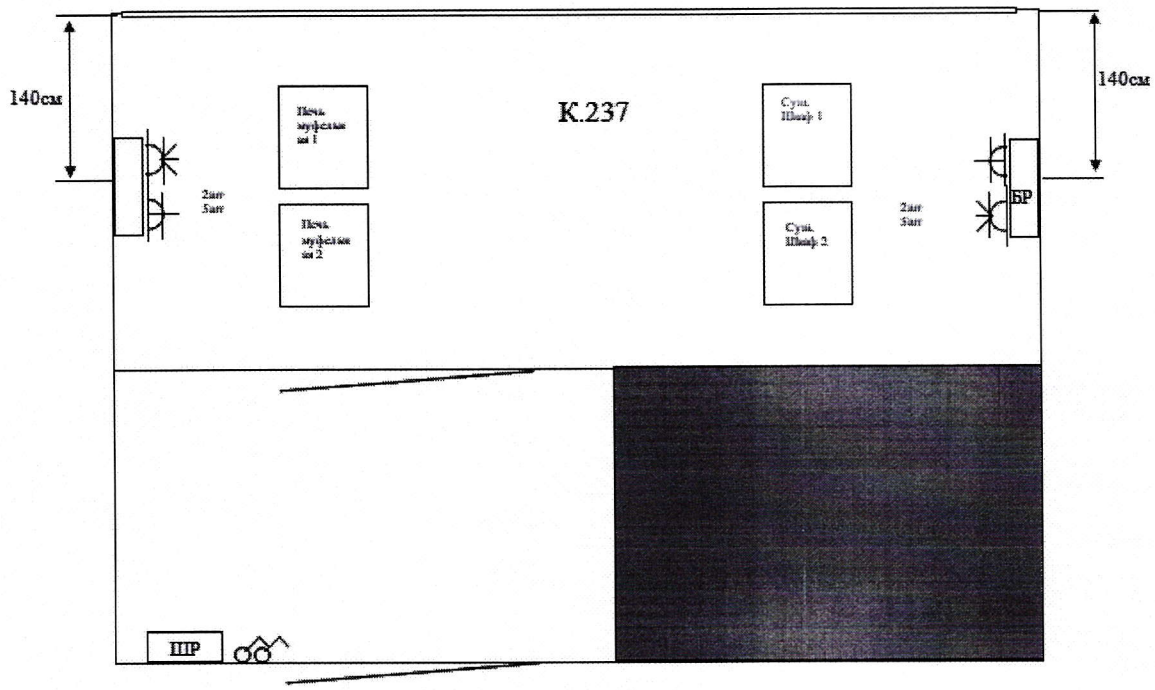


Fig. 9. Laboratory plan for heat treatment of materials (room 237).

2. Research Module (rms. 130, 136, 234)

Purpose: investigation of the physical properties of samples.

Equipment (Fig. 1, 2, 3, 5, 8, 10):

1. STEM HD-2000 (Jeol) (rm. 136);
2. DRON-9 [XRD] (rm. 136);

3. SAXS (Philips) (rm. 136);
4. Optical microscope (rm. 136);
5. UV-spectrometer (rm. 234);
6. Ellipsometer (rm. 234);
7. Solar cell characterization system (rm. 234);
8. Impedance meter R-45X (Chernogolovka, RF) (rm. 119);
9. Potentiostat (rm. 119);
10. Office desks – 4 units (rm. 130);
11. Computers – 4 units (rm. 130).

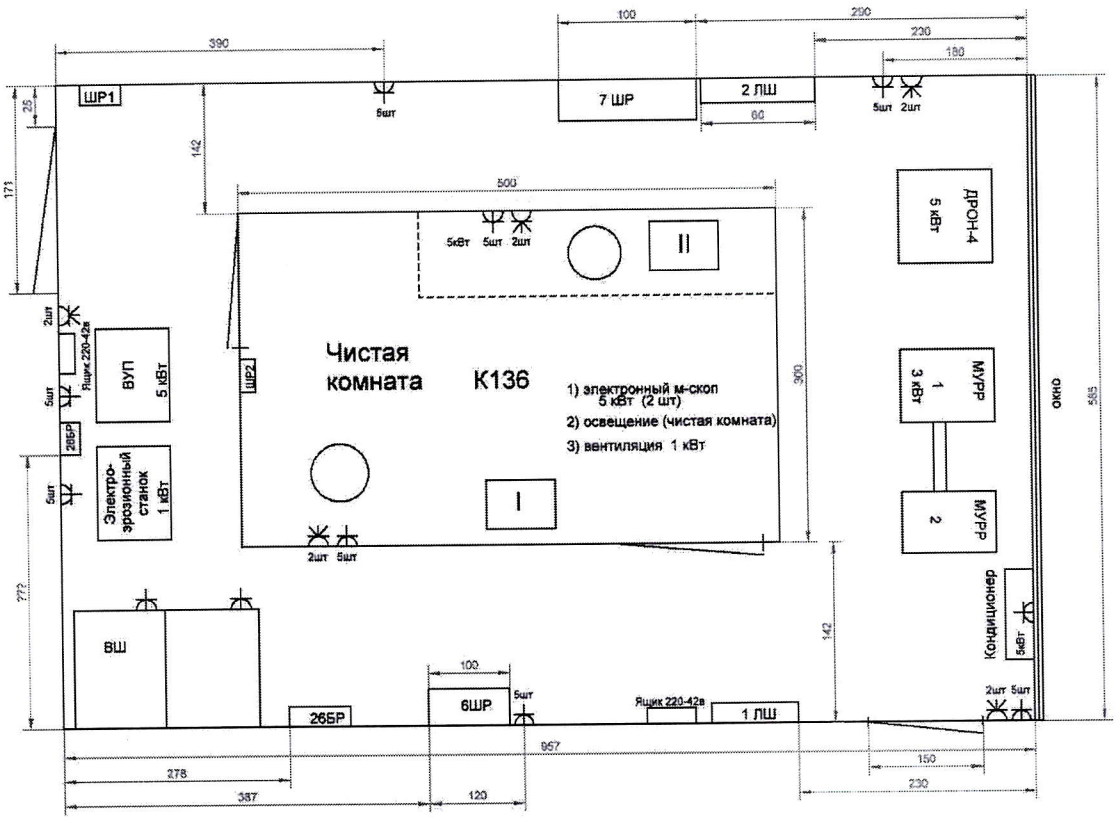


Fig. 3. Layout of the microscopy room (rm. 136).

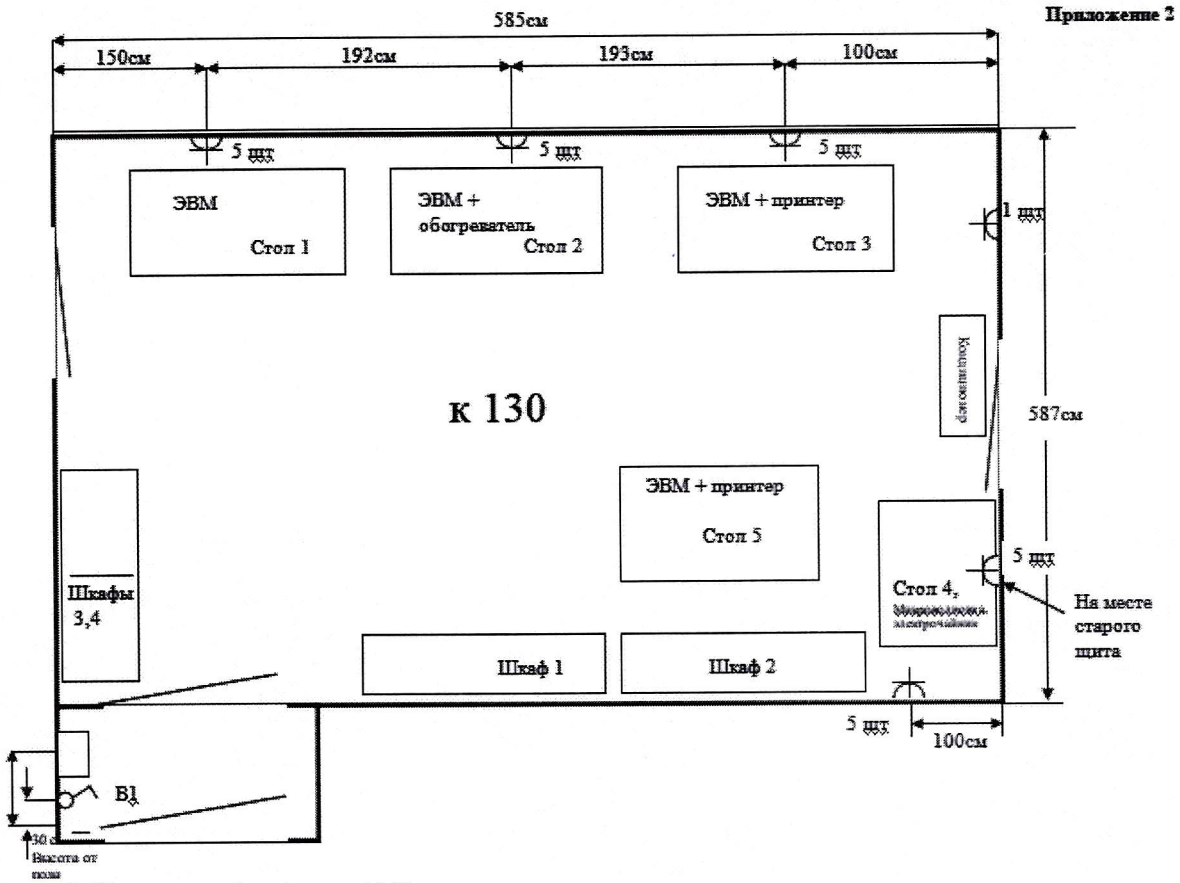


Fig. 2. Office space plan (room 130).

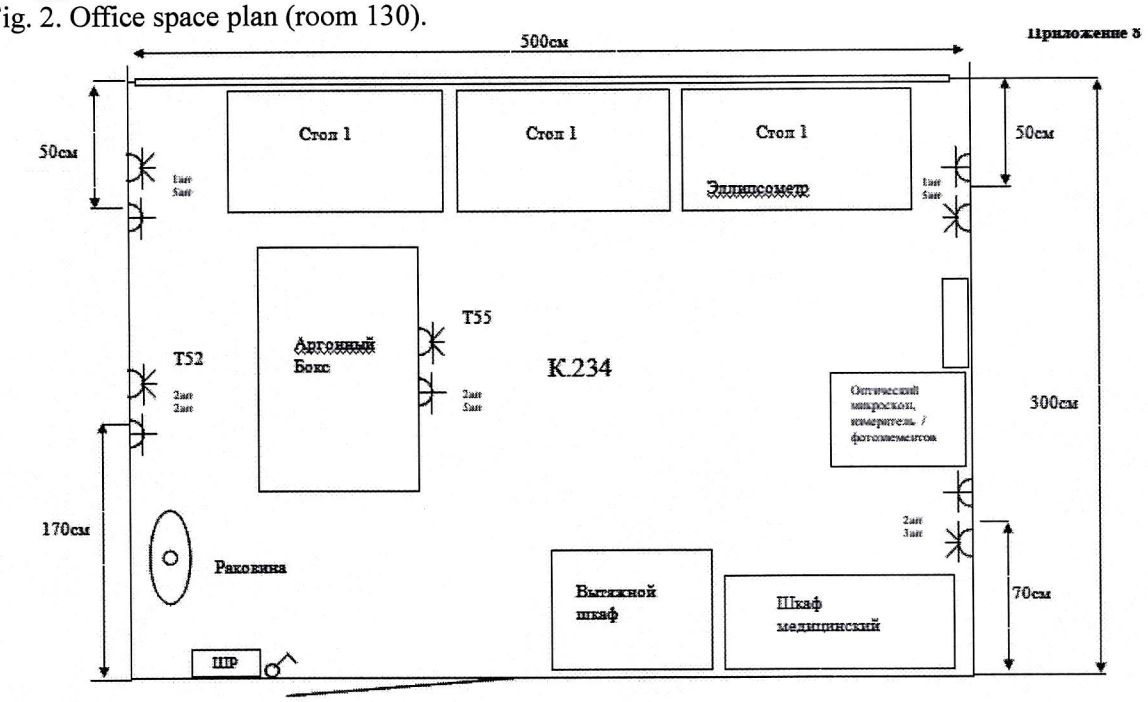


Fig. 8. Laboratory plan for chemical synthesis of materials in an inert gas environment.

3. Chemical-Biological Module (rms. 216, 217, 234, 230, 118): Equipment (Appendices 4, 5, 8, 10)

1. Drying oven for glassware (rm. 216);
2. Dryingovenforsalts (216);
3. Vacuumdryingoven (216);
4. Distiller (rm. 216);
5. Bidistiller – 2 units (rms. 216 and 217);

6. Fume hood – 3 units (rm. 216), 1 unit (rm. 234), 1 unit (rm. 118), 1 unit (rm. 136);
7. Precision balances (rm. 216);
8. Chemical equipmentandglassware (216–217);
9. Biologicalthermostat [Incubator] (rm. 230);
10. Growbox (rm. 230);
11. UV airrecirculator (rm. 230);
12. Chemical storage cabinets – 5 units (rms. 216, 217, 234, 119);
13. Metal cabinets for reagent storage (rms. 216, 234).

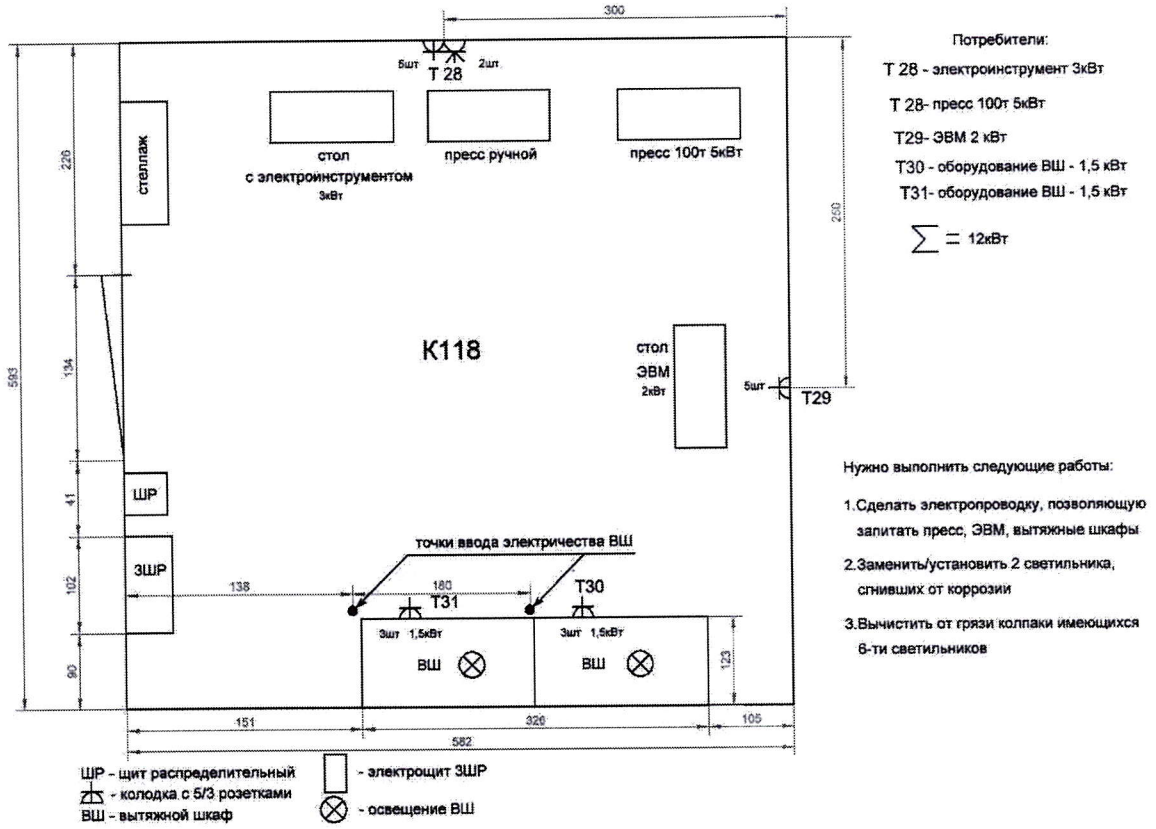
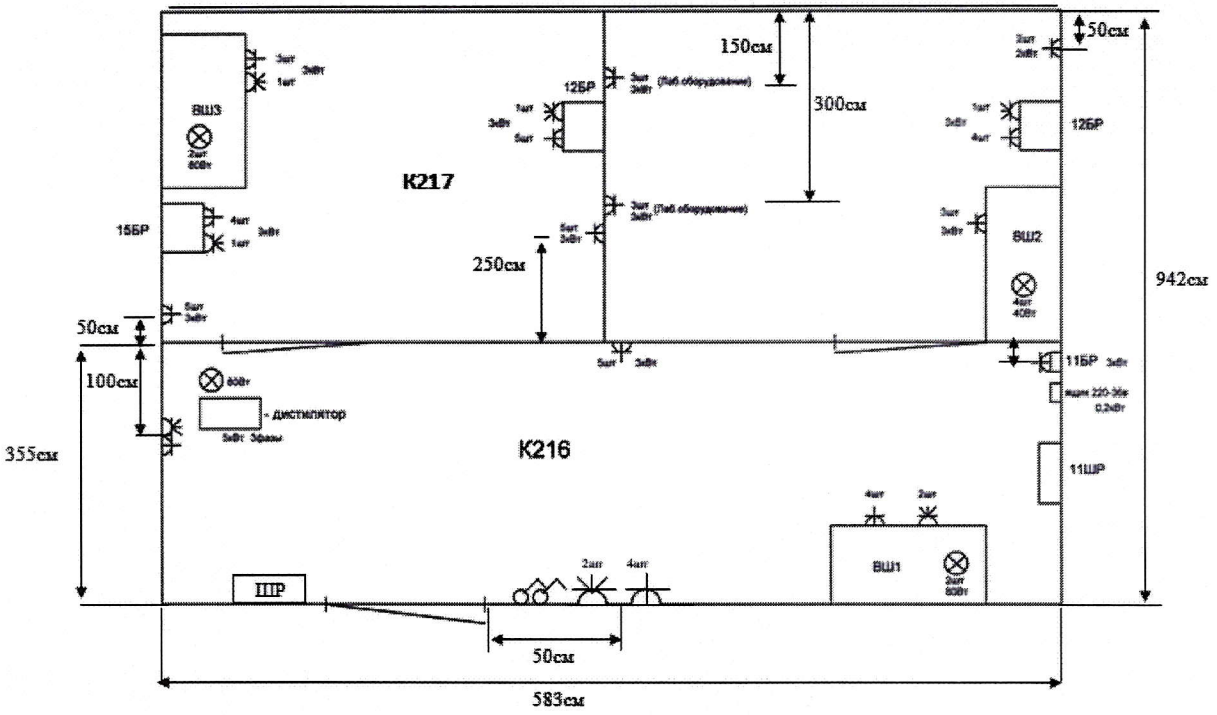


Fig. 4. Mechanical workshop (room 118).



Rice. 5. Plan of the Chemical Laboratory (rm.216-217).

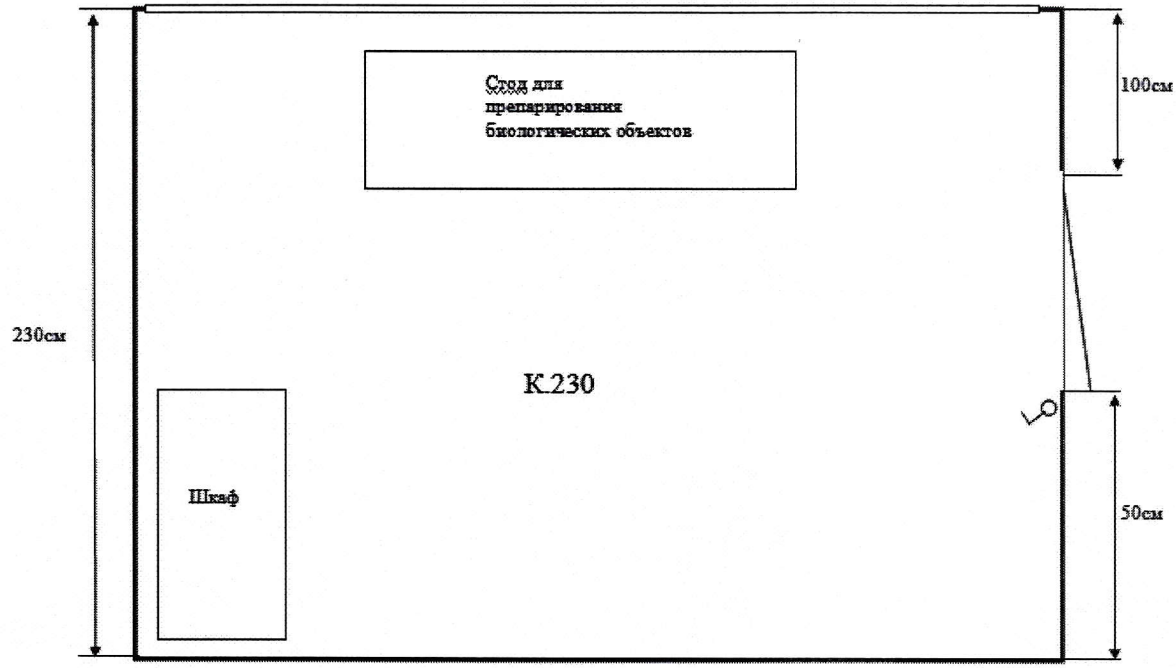


Fig. 10. Layout of the laboratory for growing mutant plant seeds.

Planned use of the equipment

Objects for Ion-Implantation Methods (RBS, PIXE, etc.)

Currently, the main challenge limiting research via ion-beam analysis (IBA) of customer samples is the mismatch between the geometry of the supplied objects (surface roughness, porosity, inconsistent dimensions, height, phase state) and the required experimental conditions.

Highly Porous Objects

The laboratory possesses all the means for monolithic consolidation via ceramic technology and subsequent surface treatment:

- **Grinder/Mill** – grinding, homogenization, and preparation of press-powders;
- **Manual press / Tensile machine** – powder compaction;
- **100t Press** – compaction under quasi-hydrostatic conditions;
- **1300 °C Furnace** – production of ceramic samples;
- **Grinding machine** – grinding and polishing of surfaces;
- **Cuttingmachine** – sampleshaping.

SuperhardMaterials

- **Vacuum system** – ion polishing of the surface;
- **Electrical Discharge Machine (EDM)** (for conductive materials) – shaping;
- **Laser cutter** – for all other materials.

OtherMaterials

- **Desktop polishing machine** – final surface finishing;
- **Laser cutter and EDM** – precision shaping of samples.

Internal Methods for Fabricating Structures for RBS

1. **Argon glove box, centrifuge, ultrasonic (US) gas-phase deposition** – production of perovskite functional structures.
2. **Vacuum system** – production of thin films via vacuum condensation.

Comprehensive Surface CharacterizationMethods

- **Ellipsometer** (optical and electronic properties);
- **Electron microscope in scanning mode** (microstructure);
- **Optical measuring microscope** (polishing quality, topology, heterogeneity size);
- **DRON-9** – crystalstructure;
- **SAXS (Small-Angle X-ray Scattering)** – geometry of phase boundaries, grain size, inhomogeneities.

Comprehensive study will allow for the rapid acquisition of sufficient information about a sample for subsequent RBS analysis. Combined with elemental composition data, this information is sufficient for the preparation of high-quality scientific papers. The speed of obtaining information on the structure and microstructure will enable technological development aimed at creating new materials. Given existing accelerator methods, it will be possible to produce radiation-resistant materials and functional materials for various applications.

Methods of Influence – Tools for RBS Analysis

In addition to accelerator-based surface functionalization, the laboratory will be capable of chemical surface etching, oxidation (heating in air), erosion in superheated steam (IMP), stress annealing, etc. Studies before and after such influences using IBA and ellipsometry will provide data on element diffusion resulting from light gas ion irradiation and information on the oxygen subsystem on the surface of nanoparticles.

Preparation of Objects for Electron Microscopy

1. **Vacuum station** – vacuum degassing of porous and biological samples; vacuum polymer impregnation of biological tissues and porous objects.
2. **Vacuum station with thermal evaporator** – carbon sputtering, fabrication of single-stage replicas, vacuum carbon contrast enhancement of surfaces.
3. **Vacuum station with magnetron sputterer** – gold contrast enhancement of fracture surfaces.
4. **Potentiostat** – preparation of metal samples via electrochemical etching.
5. **Fume hood + vacuum station with thermal evaporator** – fabrication of two-stage replicas.
6. **EDM machine** – defect-free sections in metals and superconducting superhard materials; production of metal replicas for investigating the surface structure of conductive materials.
7. **EDM machine + potentiostat** – production of replicas from conductive materials, including superhard ones.

8. **Cutting machine + grinding machine + vacuum station with ion etching module** – production of TEM replicas from ceramics and other materials.
9. **Press + vacuum system** – preparation of SEM objects from fracture surfaces.

PreparationofPrototypesandParts

- **Locksmith/mechanicaltools**;
- **3D printer**;
- **Laser cutter**;
- **Laser welding**.

Preparation of Experimental Functional Device Prototypes

- **Laser cutter** – cutting electrode grids, etc.;
- **Chemical lab** – fabrication of functional coatings, metallization of electrodes, production of functional materials;
- **Vacuum systems** – sputtering of electrodes, etc.

Laser Systems (rms. 115, 119)

Plan for using equipment located in room 115, building 120: CNC Laser Complex

- Fabrication of sample substrates for RBS and PIXE studies.
- Laser cleaning and grinding of sample surfaces to improve research results.
- Fabrication of complex-profile components without subsequent processing for the urgent repair needs of the EG-5 accelerator.

The complex features a 1 kW beam pump source, allowing it to work with non-ferrous and ferrous metals up to 8 mm thick with a declared accuracy of 50 μm. The unique capabilities of laser cutting technology allow for tasks that are inaccessible to the standard machine park of the FLNP JINR experimental production facility.

Staff: 1 CNC operator to maintain the equipment; 1 design engineer for creating models and control programs (I.A. Chepurchenko).

The room for the complex must have exhaust ventilation. Laser machines should be placed in separate rooms with restricted access. The minimum room area is determined by the equipment dimensions and the space required for operation and maintenance. A gap of at least 70–100 cm is recommended on all sides of the machine for access to the housing, optics, and communications. Ceilingheightmustbeatleast 2.5 m.

Safety:

- The room must be equipped with primary fire extinguishing agents (CO□ or powder extinguishers) appropriate for the fire class.
- Flammable materials must be stored away from the laser machine.
- The laser machine is equipped with a protective casing partially covering the work area.
- **Interlocks** — safety systems that automatically interrupt the laser (or switch it to safe mode) if the casing is removed during operation.
- **Smoke sensors** — installation of smoke sensors helps detect fires early.
- Warning and information signs indicating hazards associated with laser equipment must be installed. Personnel training on safety rules for laser cutting is mandatory.

Currently, there is no equipment of this type on the VBLHEP site.

PriorityTasks:

1. **Chemical Laboratory (216-217, 234):** Upgrade and partial replacement of laboratory furniture; installation of a UV spectrometer and other equipment for chemical analysis.
2. **Block: Microscopy (136) – Office (130):** Installation of a panel construction and associated ventilation; electrification; repair of damages post-electrification; delivery and commissioning of the electron microscope; preparation of workstations in room 130.

Conclusion

The complex of laboratory and technological equipment will allow FLNP to implement a full scientific and technological cycle for radiation materials science and powder ion-beam nanotechnologies, including:

- Synthesis of oxide nanopowders and nanoscale perovskite films, etc.;

- Fabrication of functional structures based on them (electronics, sensors, energy);
- Fabrication/preparation of samples for ion-beam analysis and electron microscopy.

The full ceramic technology cycle will be implemented, including grinding, pressing, and sintering of powder objects.

The laboratory will significantly expand the SNPN's capabilities regarding the types of objects available for study. Specifically, it will enable high-quality research on powder objects, objects with non-smooth surfaces, superhard materials, and other types of samples currently inaccessible.

The experimental methods gathered in the laboratory will allow for rapid and comprehensive analysis of the structure and microstructure of objects using both integral and local methods. In conjunction with the EG-5 electrostatic accelerator, the laboratory forms a research complex that will significantly accelerate studies on the interaction of available radiation types with matter, substantially increase the quantity and quality of scientific output, and enable technological development of scientific results for subsequent practical implementation.

Appendix 8.

Response to the RECOMMENDATIONS
of the 61st session of the Programme Advisory Committee for Nuclear Physics
June 19–20, 2025, relating to the EG-5 ESU modernization project

Modernization of the EG-5 accelerator and its experimental infrastructure: current status

Recommendation. The PAC took note of the interim report on the status of the project "Modernization of the EG-5 accelerator and its experimental infrastructure" and notes the progress achieved in its implementation. The PAC recommends resuming work on EG-5 in the basic configuration until the new elements of the high-voltage system, such as the ion source and the accelerator tube, are completed, and continuing work on upgrading EG-5, including replacing the high-voltage system in 2026–2027.

The PAC also noted that the proposed EG-5 machine, delivering low-energy, high-current light isotopes, is highly suited for reactions of nuclear astrophysics, especially, proton capture reactions suitable for studying the so-called p-nuclei and also reactions of the Big Bang nucleosynthesis. The PAC also feels, that if reactions of nuclear astrophysics are to be pursued, definite steps should be taken to provide cooled target ladders and also arrangements for gaseous targets (1). The PAC recommends that the performances of the EG-5 accelerator be compared with similar modern facilities worldwide (2).

1. The solid target cooling system was supplemented with a chiller, which made it possible to increase cooling efficiency and temperature stability.

2. The global position of the EG-5 accelerator among modern electrostatic and tandem facilities.

According to the IAEA Accelerator Knowledge Portal, the global accelerator infrastructure comprises approximately 578 registered sites, a significant portion of which are low- and medium-energy accelerators, including electrostatic accelerators (Electrostatic Accelerators).

Electrostatic machines (primarily Van de Graaff generators and pelletrons) traditionally set an upper limit on operating energies of approximately 10–20 MeV, depending on the type and design. However, relatively few of these facilities simultaneously:

- possess high beam energy and spatial stability;
- enable the implementation of precision options such as a nuclear microprobe;
- provide high fast neutron output fluxes.

There are several dozen such facilities worldwide, primarily concentrated in large national and university centers.

Key analogues: global tandem and pelletron facilities.

The main competitors of the EG-5 at the global level are the tandem accelerators of HVEE (Netherlands) and NEC (USA), as well as a number of unique scientific complexes, such as the facilities at HZDR (Germany).

Typical representatives of this class:

- HVEE Tandetron — a series of tandem electrostatic accelerators optimized for ion beam analysis (IBA) methods, with energies up to several MeV and currents of approximately 10–50 μA.
- NEC Pelletron — pelletron tandems operating in the energy range of ~1–3 MeV and higher, with an emphasis on sensitive materials analysis and isotope research.

Key technological advantages of EG-5.

Unlike most modern commercial tandem accelerators, EG-5 is a single-stage accelerator, where ions are accelerated in a single electric field without a charge exchange stage on the target. In tandem accelerators, such a stage inevitably introduces additional energy spread and ion scattering.

The absence of an intermediate target in EG-5 ensures a naturally narrow beam energy distribution, which is critical for:

- resonance NRA (Nuclear Reaction Analysis) — measuring light elements (O, N, C, Li) with high sensitivity and accuracy;
- low-energy nuclear physics — studying reactions in narrow energy ranges, where energy resolution plays a crucial role.

Using deuteron and lithium targets, fast neutron fluxes of ~10^9 n/s cm² with energies of ~4–5 MeV are achieved. This makes the EG 5 an extremely effective tool for:

- neutron materials science (studying radiation damage and the behavior of materials under flux);
- radiation medicine and biology (irradiating cells and tissues with fast neutrons).

Unlike most Western analytical tandems, which are optimized primarily for low currents and IBA mode, the EG 5 maintains a competitive advantage specifically in high-current applications and neutron generation.

Modern facilities from HVEE and NEC are often implemented as closed systems:

- proprietary control software,
- specialized modules and components,
- dependence on the manufacturer's service engineers.

In the current geopolitical environment, this leads to significant risks in service and logistics. In contrast, the modernized EG-5 is built using an open architecture:

- domestically and commercially produced microwave ion sources,
- fiber-optic communication lines and domestic automation systems,
- unified monitoring and control solutions.

This approach ensures the complex's economic autonomy and maintainability, allowing it to expect stable operation for 20-30 years without dependence on foreign service centers.

It has been demonstrated internationally that accelerator efficiency directly depends not only on beam parameters but also on the associated infrastructure and analysis methods. Centers like Surrey (UK) or CNA (Spain) demonstrate high integration of ion irradiation with electron microscopy, spectroscopy, and electrophysical measurements.

At JINR, the "full research cycle" concept for EG-5 is being implemented by 2026:

- sample preparation (specialized chemical laboratory and vacuum systems);
- modification and irradiation at EG-5 with various ions;
- analysis using nuclear physics and related methods:

RBS, PIXE, ERD, PIGE,

- electron microscopy (STEM, SEM),
- impedancemetry and ellipsometry for the electrophysical properties of irradiated materials.

This level of integration makes the EG-5 complex comparable in functionality to the best European centers of excellence in experimental nuclear physics, radiation materials science, and nanotechnology.

Despite the noted advantages, EG-5 also has a number of features that can be considered **weaknesses:**

In recent years, leading manufacturers (HVEE, NEC) have implemented fully automated control systems ("one-button operation"), remote monitoring services, and advanced diagnostics. Unfortunately, a similar level of automation is not possible for EG-5 at this stage of modernization.

Therefore, the modernized EG-5 as part of the accelerator complex will be a competitive device with unique features.