Ministry of Education and Science of the Russian Federation
Federal Autonomous Educational Institution for Higher Professional Education
National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)

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«УТВЕРЖДАЮ»
И.О. ДИРЕКТОРА «ИНСТИТУТА ЛАЗЕРНЫХ И ПЛАЗМЕННЫХ ТЕХНОЛОГИЙ»

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Strategic Academic Unit

INSTITUTE FOR LASER AND PLASMA TECHNOLOGIES (LAPLAS)

Strategic plan of the educational and scientific research development in 2016–2018

Moscow

2016

I. Strategic priorities of the LAPLAS Institute

1. Global challenges for the LAPLAS Institute

Nowadays the scientific research and corresponding technologies of generation and application of light and other radiation types have become one of the driving forces of the world economy innovative development. The experts consider laser and radiation technologies to be able to solve many of the problems that humanity faces in the fields of energy production, industrial production, health care, informational support, environment protection, and security protection. Laser and radiation technologies have immense innovative capabilities. Thousands of high-tech companies around the world operate in this sector. Over the last 5 years, production growth rate in the field of laser and radiation technologies in European Union (EU) is twice the growth rate of the gross national product (GNP). In the USA, the exploratory research and development in this field is being actively supported by the DARPA agency and through the national programs. According to the US experts, 25% of recent US inventions of prime importance were based on the laser optics technologies. In China, 5000 laser optics production enterprises have been established over the last 15 years, while the annual production growth rate exhibits an average of 25−30%. The South Korean Ministry of Science and Technology annually spends 30% of the overall scientific funding on research in the field of laser and radiation technologies.

Unfortunatelly, despite possessing substantial scientific and industrial potential in the field of laser radiation technologies, Russia is inferior to advanced countries in the scale of their practical applications. Demand for laser, plasma, and radiation technologies has emerged in almost every sector of Russian economy, including the topical fields of Russian nuclear energy, production, and medicine.

Institute for Laser and Plasma Technologies faces the ambitious task of transforming scientific research and educational activities for the purpose of:

- ensuring parity between Russia and the developed countries in the fields of laser, plasma and radiation technologies;
- increasing demand for educational programs of the LAPLAS Institute in the world market of educational services.

To solve this problem, the actions are to be developed to overcome the following set of global challenges, which the Institute faces in the areas of research, education and innovation:

1. Russia has noticeably slower pace of development in the fields of laser, plasma and radiation technologies. There is a real threat of loss of basic and critical technologies in this segment of science and technology. By now, we already have ten specialists in Germany, and more than 100 — in China, per one corresponding Russian specialist.

2. Environmental issues necessitate the development of new highly efficient environment-friendly technologies
3. New breakthroughs in science and technology are impossible without increasing the cooperation of scientific disciplines, the convergence of knowledge and technology, and the volume and depth of multi- and interdisciplinary research.
4. The emergence of the "brain circulation" trend arriving to replace the trend of "brain drain" determines the need for academic and research staff mobility.
5. The presence of unique research infrastructure at leading universities favors a natural basis for their inclusion in the program of international scientific cooperation, formation of the international scientific consortia and centers of collective use on their base, and participation in large international collaborations on the development, creation and operation of the megascience-class research facilities.
6. In the context of growing importance of open science concepts for the economic development of the country, early research and rapid implementation of the results become a competitive advantage.
7. The rapid change of technology and automation of production requires fast human adaptation to new market conditions and emergence of the need for lifelong learning.
8. Changing of values in society in relation to education and strong motivational differentiation of students lead to low efficiency of the "batch" decisions in education and emphasize the importance of individual educational trajectory.

2. Strategic goal of LAPLAS Institute

The strategic goal of the LAPLAS Institute is to become the best in Russia and internationally recognized leading scientific school and the core of innovative development in laser, plasma and radiation technologies, with unique educational programs, essential both for the Russian and world markets of educational services.

3. The main objectives of the LAPLAS Institute

In the sector of scientific research:

- Research and development in the fields of laser, plasma, radiation and beam technologies and their applications to the energy production, industry, medicine and the life sciences.
- Research in the field of environment-friendly energy production based on controlled nuclear fusion.
- Research and development in the field of high-power lasers, physics of the interaction of ultra-intense optical fields with matter, attosecond optics.

- Research and development in the field of compact (table-top) laser-plasma particle accelerators for proton therapy.
- Research of new functional materials using synchrotron radiation and free electron lasers.
- Research and development in the field of optical information processing, radiophotonics, optical, laser and quantum metrology.

As a result of research activities in the next 3–5 years, the following product range can be specified:

- New functional gradient materials with the use of nanopowders of refractory compounds and technology of direct laser epitaxy.
- Experimental kilojoule-level laser facility superior to the world analogues by its technical parameters and functionality and enabling conducting research of the ultra-intense laser-matter interaction in previously inaccessible range of parameters in relation to fundamental and applied problems in the fields of extreme states of matter, physical principles of novel energy technologies, and laboratory astrophysics.
- Photonic analog-digital systems with an effective number of bits up to 10 for the signal processing systems with over 10 GHz bandwidth that is an order of magnitude higher than the current capabilities.
- Portable radioisotope power sources based on nanostructured thin film thermoelectrics with output power of up to hundreds of microwatts and service time up to tens of years.
- Energy-efficient electron accelerators with energy of 2–10 MeV for applications in sterilization, industrial inspection, modification of materials, and metrology.
- Micromechanical devices based on amorphous-crystalline alloys with reversible shape memory effect for gripping and moving the microscopic objects with sizes of 10 to 200 microns which may be used in microelectronics, robotics, microbiology, and for diagnostic and implantable microbiochips and other integrated microdevices.
- Highly productive magnetron sputtering facilities for precise deposition of high quality coatings. Combined technologies of high-current impulse magnetron sputtering and magnetron discharge with hot cathode will enable deposition of dense films of metals and their compounds at the rate of ~ tens of microns per minute, far superior to conventional techniques, for applications in microelectronics, industrial production, medicine, and many others.
- New type of plasma-beam generators for soft etching and modification of hetero- and nanostructures. Precise control of the mean energy of ion flux impinging the treated surface in the range of 10–100 eV, will ensure surface modification (etching or film deposition) with minimal fraction of radiation defects. Due to non-collisional mechanism of electron heating in

the plasma-beam generators, high anisotropy of ion flux and etching is guaranteed that is superior to capabilities of conventional industrial technologies involving radiofrequency and microwave discharges.

In the educational area:

- Training of highly qualified specialists according to the prospective development of laser, plasma and energy saving technologies, in the framework of the technological renovation of the Russian enterprises, creation of the megascience-scale facilities, including Russian megajoule-energy level laser facility, as well as NICA, ITER, FAIR, and XFEL projects.
- Increasing the demand for the educational programs among students and employers due to:
  - Introduction of team and project education forms in order to foster the crucial skill of cooperation;
  - Elaboration of integrated study program accounting for the need for comprehensive development of a person;
- - Establishing the international educational environment due to:
  - Involvement of foreign professors and researchers into the educational programs of the LAPLAS Institute;
  - Involvement of foreign students in the format of training, as well as master and postgraduate studies;
  - Development of international academic mobility of the LAPLAS Institute's students and faculty, in the framework of joint scientific programs and research projects realization;
  - Extension of the program of foreign training and summer schools for students and postgraduates of the LAPLAS Institute.
- Organizing training of students in the leading Russian and foreign laboratories, scientific centers for laser, fusion, and radiation acceleration, and in the international organizations.
- Improving the Institute's own educational and experimental basis.
- Formation of the unique application-oriented special educational modules, which can serve either as parts of the basic educational program of a student, or as additional modules of expert-level education.

In the innovative activities:

- Development and industrial adoption of new additive technologies and facilities with semiconductor, fiber lasers, as well as laser, plasma, and acceleration technological devices and facilities.

- Creation and adoption of the technology for material studies under high pressure and high temperature conditions (aerospace and nuclear technologies).
- Research and development (R&D) activities in the framework of collaboration with Rosatom State Corporation and the Russian Academy of Sciences (RAS) institutes in building Russian megascience-class megajoule-level laser facility, as well as NICA, ITER, XFEL, HiLumi-LHC, and FCC projects.
- Launch of the educational programs to form highly-qualified specialists prepared to run startup companies.

4. Key strategic distinctions of the LAPLAS Institute

In the field of scientific research, LAPLAS Institute:

- Possesses the Russian best laser equipment for development of novel industrial technologies.
- Is one of the acknowledged Russian leaders in the areas of optical digital systems and optical data processing methods including the fields of computer and digital holography, diffraction systems for imaging and image processing.
- Holds unique plasma technologies adopted by the Russian industries.
- In the industrial partnership with Rosatom State Corporation is creating the Europe's most advanced laser facility at NRNU MEPhI for extreme states of matter research and fusion energy studies grounded on the unique technologies realized in the next-generation Russian megajoule-level laser facility currently under construction.
- Holds unique competences in the area of research and construction of charged particle accelerators, adopted by the large megascience-class accelerator facilities as well as by the industrial accelerators.
- Is one of the world leaders in the quantum metrology studies.
- Participates in the international program of building the ITER fusion reactor.

In the field of education, there will be the following LAPLAS Institute distinctions:

- International Research and Education Center «International User Laser Facility ELF-MEPhI», providing high competitiveness of educational programs on the international market of educational services due to the presence of unique experimental facilities for research in the fields of extreme states of matter, radiation technologies, and super-strong light fields.
- Research and Education Center "Advanced laser technology", providing high competitiveness of educational programs for training highly qualified specialists with industry-oriented

competencies (including the format of additional vocational training) for the industrial enterprises of the Russian Federation.

- The unique community of graduates, providing the investment support for the research and development projects realized by the Institute, and facilitating the successful employment of graduates.

5. Contribution of the LAPLAS Institute to the University development in 2016–2018

By its activities, the LAPLAS Institute ensures the NRNU MEPhI's leading positions in the priority directions of environment-friendly energy production, energy saving technologies and new materials research. Fulfilling the major objectives of the LAPLAS Institute fits into the roadmap of NRNU MEPhI Competitiveness Growth Program under "…developing of new technologies and products in non-energy markets: beam, plasma, and laser technologies".

Scientific, educational, and innovative activities of the Institute for Laser and Plasma Technologies aim at accomplishing goals and objectives of the Action Plan of Competitiveness Growth Program, including achieving the indicators of the Action Plan:

- concerning the educational activities:
  - increase of the fraction of foreign professors, lecturers and researchers in the number of scientific and educational personnel, including those Russian citizens holding PhD degrees from foreign universities;
  - increase of the students' fraction enrolled in master's programs and in the training of scientific and educational staff in the postgraduate course, holding a bachelor's degree, a specialist's diploma or a master's diploma issued by other organization;
- concerning activities in research and innovation:
  - increase of the number of publications in scientific journals included in the Web of Science and Scopus database;
  - increase in the share of income from non-budgetary sources in the structure of NRNU MEPhI revenues;
  - increase of the amount of research and development projects per single scientific and educational employee;
  - increase in the proportion of undergraduate and graduate students involved in the innovative activities and scientific research;
  - and others.

Thus, the LAPLAS Institute with its activities contributes to NRNU MEPhI advance to the status of the world-class scientific and educational center with stable reputation, and its further development in this direction.

II. Development of the staff and organizational structure of the LAPLAS Institute

1. Target number of scientific and educational personnel and its trends for 2016–2018[1]

Formation of the scientific and educational personnel (SEP) of the LAPLAS Institute will be performed via three channels:

- admittance of SEP from the structural subdivisions within the LAPLAS Institute (departments, laboratories, etc.);

- admittance of SEP from the Office of Educational Programs of NRNU MEPhI;

- admittance of SEP from outside NRNU MEPhI.

Target number of SEP by the end of 2018 is 85 positions. The number of LAPLAS Institute scientific and educational employees is planned to increase by 30% as compared to 2016. Formation of the SEP at the first stage (in the transition period of 2016), will involve highly qualified specialists from within the LAPLAS Institute and from the NRNU MEPhI departments outside the LAPLAS Institute. For general education, engineering (partly), and humanitarian disciplines, faculty from the NRNU MEPhI Office of Educational Programs will be involved.

Change of the scientific research topics and improvement of the educational programs will require involving Russian and foreign SEP from outside NRNU MEPhI.

	unit	2016	2017	2018
SEP number in SAU by the end of the period	positions	65	75	85
	employees	98	116	131
SEP admittance to SAU during the period				
- from the Office of educational programs (OEP)	positions	2	—	—
	employees	2	—	—
- from within SAU	positions	63	—	—
	employees	96	—	—
- from MEPhI outside SAU	positions	—	2	2
	employees	—	2	2
- from outside MEPhI, Russian SEP	positions	—	4,5	6
	employees	—	9	—
- from outside MEPhI, foreign SEP	positions	—	3,5	2
	employees	—	7	4

The LAPLAS Institute involves foreign professors, lecturers and researchers both in the educational programs of the institute and as the scientific co-advisors of the master degree students and postgraduates. In its development process, LAPLAS Institute is planning to increase the fraction of foreign lecturers up to 24% of the total number of lecturers of the Institute by 2020.

	unit	2016	2017	2018
Number of foreign SEP in the SAU by the end of period	positions	13	16,5	18,5
	employees	26	33	37

[1] From here on the indices of the plan are calculated on the basis of current situation in 2016 and accounting for the transition period. In case of principal changes of internal or external conditions, the indices can be recalculated, and the Strategic Development Plan for 2016–2018 can be adjusted.

Fraction of foreign SEP in the SAU by the end of period	%	21	22	22
Number of faculty, engaged in the teaching from the SAU	employees	89	95	100
Number of faculty, engaged in the teaching from the OEP	employees	60	60	60
Number of faculty, engaged in the teaching from the SAU contour	employees	109	90	80

2. **Development of the organizational structure of the LAPLAS Institute in 2016–2018**

2.1. During the transition period in 2016, the contour of the LAPLAS Institute was formed, which includes the following NRNU MEPhI subdivisions:

- Department of Laser Physics
- Department of Plasma Physics
- Department of Theoretical Nuclear Physics
- Department of Laser Thermonuclear Fusion Physics
- Department of Solid State Physics and Nanosystems
- Department of Electrophysical Facilities
- Laser Center of NRNU MEPhI
- Plasma-Surface Interactions and Plasma Technologies Laboratory
- Department “Physical and technical problems of metrology”

2.2. Development of the organizational structure of the LAPLAS Institute in 2016-2018

Formation of the LAPLAS organizational structure will be conducted in three key directions:

- R&D activities;
- education;
- strategic planning.

Research structure will be formed on the basis of the creation of the research departments for those research areas having high scientific and innovative potential. In its turn, the structure of departments is formed for three types of units:

- Research and Education Center — a structural subdivision with a strong infrastructure and research laboratory facilities, conducting a wide range of interdisciplinary research and technological activities.
- International research laboratory — a structural subdivision headed jointly by Russian and foreign scientists, whose research activity aims at addressing a topical problem and is carried out in international cooperation.
- Research Laboratory — structural subdivision headed by a staff member (SEP), whose research activity is related to the topical scientific and/or technological problem.

The number of structural units of the LAPLAS Institute in 2016–2018

	unit	2016	2017	2018
Number of subdivisions (departments)	number	7	7	7
Number of scientific and educational centers	number	1	2	2
Number of international laboratories	number	4	6	6
Number of laboratories	number	13	15	15

2.3. Target list of the LAPLAS Institute structural subdivisions by 2018

1. Department of Laser Physics and Technology

   Research and Education Center “Advanced laser technology (Laser Center MEPhI)”

   Laboratory of additive laser technologies (to be established in 2017)

   Laboratory of optical information processing, holography, and radiophotonics

   Laboratory of materials and structural analysis

2. Department of Plasma Physics and Plasma Technology

   International Laboratory of plasma-surface interactions and plasma technologies

   International Laboratory MEPhI-ITER (to be established in 2017)

   Laboratory of pulsed processes and high-temperature plasma

   Laboratory of plasma radiation effects on materials for nuclear, thermonuclear, and electrophysical facilities

3. Department of high-power lasers and extreme light fields

   International scientific-educational center “High-power lasers and extreme states of matter (Experimental laser facility ELF-MEPhI)” (to be established in 2017)

   International Laboratory “Radiation diagnostic techniques and radiation technologies using ultra-intense laser radiation”

   Laser Diagnostics Laboratory.

4. Department “Physics and Technology of New Materials”

   International Laboratory “Research of condensed matter and nanostructures using synchrotron radiation and free electron lasers”

   Laboratory “Electrophysical and magnetic phenomena at low temperatures”

   Laboratory “Functional nanoscale structures”

   Laboratory of quantum methods in solid state physics

5. Division of Theoretical Physics

International Laboratory “Simulation of physical processes in the extreme light fields”. (To be established in 2017)

Laboratory “Theory of many-particle systems and space plasma physics”

6. Department “Charged particle accelerators and radiation technologies”

Laboratory “Dynus” (“Dynamics in accelerators”)

Laboratory of microwaves

Laboratory of high-power microwave energy production

7. Department of Quantum Metrology

International Laboratory “Quantum Metrology”

Laboratory of analytical support for research of new functional materials

Laboratory of quantum standards of time and frequency with ultra-cold atoms and ions (to be established in 2017).

2.4. For the development of the educational activities of the LAPLAS Institute and its management, the Educational Department is created targeting the following tasks:

- Providing support for LAPLAS students, namely:
  - formation of groups for educational programs;
  - individual training plans;
  - control of the quality of education;
  - the appointment of scholarships;
  - issues of residence;
  - alerting students about various competitions and grants;
  - conflict resolution.
- Managing the LAPLAS educational programs; coordination and organization of educational process:
  - Developing and updating the educational and methodical complex of disciplines (EMCD), their documentary support (licensing, accreditation);
  - Matching the contents of programs and competences obtained by students in the learning process with employers, developing criteria for competency assessment;
  - recruitment of students in the LAPLAS educational programs;
  - selection and allocation of educational staff according to educational programs.

- Promoting the LAPLAS educational products in the Russian and world markets of educational services.

2.5. To generate and accomplish the strategic objectives of the LAPLAS Institute, the Strategic Planning Department is established whose functionality includes:

- Analysis of key trends that facilitate LAPLAS Institute development in the research, education and innovation.
- Coordination of activities that contribute to the financial stability of the LAPLAS Institute.
- Development, organization and coordination of marketing and presentation activities of the LAPLAS Institute.
- International activities aimed at addressing the strategic and operational objectives of the LAPLAS Institute in the field of internationalization of research and educational activities

III. Development of the educational programs of the LAPLAS Institute

Development of the educational activities of the LAPLAS Institute is planned to simultaneously cover two major directions, besides standard programs currently being offered by the Institute.

Firstly, increasing the demand for educational programs due to development of the so-called Honor programs (BSc), aimed at enhanced fundamental grounding and training in the area of Computer science as an essential competence of modern scientists. The graduates of this program are directed towards the scientific activities in the field of advanced research on the LAPLAS Institute topics. The program aims at development of the Institute's scientific schools thanks to the problem based learning technique.

Features of the Honor program:

- Improved basic knowledge due to involvement of more complicated problems into the educational process;
- Effective educational programs of English language with opportunity of applying for PTE, TOEFL, FCE, and IELTS certificates;
- Compulsory training in the leading scientific centers.

Secondly, improvement of the educational activities connected with the industrial needs. The driving force of such program development in the LAPLAS Institute will be ensured by the "Learning factory" project in the field of laser technologies that is to be established and developed starting from 2017. Different levels of the educational activities will be territorially distributed:

- At the Moscow NRNU MEPhI platform, R&D center will be established for training of highly qualified personnel and innovative development. Educational programs for the R&D center will be elaborated in compliance with CDIO standards, grounded on the concept that creation and

development of products and systems throughout their lifecycle is a crucial context of the engineering education.

- In Obninsk, a training center for technical staff is planned to be founded close to the factory of laser materials production that is now being deployed. The quality of the training is to be ensured by fostering the students' participation in the World Skills international project, which is an international platform for exchanging experience and best practices among professionals hence acting as an effective benchmarking tool for professional training.

A remote scenario is also planned for the Learning factory operation, interconnecting R&D center and the production site for the efficient accomplishing of production goals and implementation of innovations.

Educational program of the Learning factory will be constructed on new principles essentially different from those of the conventional department programs, where the program depends on the availability of a certain lecturer within the department. New program is constructed on the ground of need for development of required competences and implies search for and involvement of those specialists who possess the target competences. Since the R&D center is closely connected with the condensed matter physics, plasma technologies, and radiation technologies, the program will become the instrument for uniting the R&D branches within the LAPLAS Institute.

The observed shift of the educational programs, ensuring active cooperation with industry, to the laser technology area is an induced step since the LAPLAS Institute's resources are limited, while this area has a certain customer capable of investing in the educational program development. At the development stage following the Learning factory launch, after gaining the experience in this field, the corresponding activities are planned to extend in the plasma and radiation technology sectors.

Standard educational programs implemented in LAPLAS will be upgraded by introduction of new educational technologies and remote education options. Below, the data illustrating the change of students' contingent, number of educational programs, and their orientation is presented.

1. Structure of the educational programs of the LAPLAS Institute and principles of their modernization

Number of educational programs implemented in 2016–2018

Number of educational programs implemented by SAU	unit	2016	2017	2018
undergraduate courses	number	12	15	11
master courses	number	13	18	21
specialist courses	number	1	1	1
postgraduate courses	number	5	7	9
additional professional education	number	-	3	7

In the LAPLAS Institute, along with modernization and updating of all ongoing educational programs of undergraduate, graduate, and postgraduate courses, new programs are planned to be developed in new training areas.

Among the main principles of the forthcoming modernization of implemented programs as well as of new programs organization, there are:

- Consecutive translation of lecture courses and and classes into English.
- Involvement of leading foreign experts and professors in the study process, particularly in new areas of physics and technology of lasers, plasmas, and accelerators.
- Finding the optimal combination of remote lectures with the effective control of the knowledge level and laboratory courses involving complex laser, plasma, and electrophysical installations.
- Compulsory industrial internship (for undergraduates) and six-month training (for masters) at the enterprises of the industrial partners for professional training with industry-oriented competences.
- Six-month internship in the leading domestic and foreign laboratories, scientific laser and fusion centers and international organizations for training of highly qualified specialists with competences in scientific research.
- Enhancing the educational standards' fraction of skills related to mathematical modelling of physical processes, development and application of computer simulation of complex objects, such as the international ITER reactor and laser-plasma facilities for inertial fusion, accelerator complexes NICA, LHC, FCC, SPES and others.
- Introduction of modules for goal-setting, self-organization, and communication organization, in the educational process.
- Frontal workshop on the basics of all LAPLAS Institute's technologies, compulsory for undergraduate programs.

2. Development and implementation of new educational programs, within the framework of promising scientific and technological tasks, taking into account the needs of the Russian economy

Development of new programs in 2016−2018:

Программа	Уровень подготовки	Партнеры
Laser and plasma industrial technologies	Master courses	Fraunhofer Institute for Laser Technology, National Research Center "Kurchatov Institute", IPG Photonics, Bauman Moscow State Technical University, National University of Science and Technology MISiS,
High-power lasers and laser fusion	Master courses	Russian Federal Nuclear Center – VNIIEF, LPI RAS, Prokhorov General Physics Institute, Russian Academy

		of Sciences, GSI Darmstadt Germany
Quantum metrology	Master courses	PTB (Germany), MPQ (Germany), NIST (USA), LPI RAS, VNIIFTRI
New quantum phenomena of complex materials	Master courses	Rome Center of Materials Science RICMASS (Rome, Italy)
Computer modeling of processes in plasma	Postgraduate courses	University of California, San Diego (USA) National Research Center "Kurchatov Institute" Keldysh Institute of Applied Mathematics (Russian Academy of Sciences)
Physics and technology of nuclear fusion with magnetic confinement	Master courses	Erasmus Mundus programme, National Research Center "Kurchatov Institute", Troitsk Institute For Innovation & Fusion Research
Physics of extreme light fields	Master courses	University of Bordeaux (France), Universität Rostock (Germany), Ludwig-Maximilians-Universität München, (Germany)
Plasma-surface interactions in fusion devices	Postgraduate courses	Erasmus Mundus programme, FZJ Uelich, IPP Garching, CEA Institute for Magnetic Fusion Research, National Research Center "Kurchatov Institute", Troitsk Institute For Innovation & Fusion Research

3. International component of educational programs

Number of joint international programs implemented in SAU	unit	2016	2017	2018
- undergraduate courses	number	—	1	1
- master courses	number	—	2	3
- specialist courses	number	—	—	—
- postgraduate courses	number	1	3	5

Number of SAU programs with international accreditation	unit	2016	2017	2018
- undergraduate courses	number	—	4	7
- master courses	number	—	1	2
- specialist courses	number	1	1	1
- postgraduate courses	number			

4. Online education

Number of MOOC on international platforms	unit	2016	2017	2018
- Coursera	number	—	2	5
- edX	number	—	1	2
Number MOOC on Russian platforms				
- MEPhI educational portal	number	—	3	7
- Open Education	number	—		
- other	number	—	2	6

5. Number and structure of the students contingent

Number of SAU students of SAE by the end of period	unit	2016	2017	2018
- undergraduate courses	number	194	190	185
- master courses	number	121	150	180
- specialist courses	number	40	55	70
- postgraduate courses	number	109	120	130

	unit	2016	2017	2018
Number of foreign students in SAU by the end of period	number	28	60	85
Fraction of foreign students in SAU	%	11	12	16

IV. Development of scientific research in the LAPLAS Institute

Research activities development in the LAPLAS Institute grounds on the medium- and long-term forecasting of global science and technology trends and is aimed at developing an active Russian industrial policy of the economy re-industrialization in order to create completely new products ensuring technological parity of the Russian Federation with the advanced countries and actively influencing the development of the global markets of technologies and high-tech products. In this connection, laser, plasma, and radiation technologies are among the most promising areas of technological development of Russia.

The strategic directions of the scientific research development in the LAPLAS Institute are:

- Energy-saving, high-performance laser, plasma, and radiation technologies;
- High-power lasers, extreme light fields, environment-friendly energy production based on controlled nuclear fusion;
- Optical information processing, radiophotonics, optical, laser, and quantum metrology.

Energy-saving, high-performance laser, plasma, and radiation technologies

LAPLAS Institute holds large material and technical capacities to carry out scientific research and development work in the fields of laser, plasma, and radiation technologies, in particular:

The automated laser technological complexes with continuous and pulsed fiber, solid-state, and gas lasers with average power up to 10 kW, performing all the main technological operations (cutting, welding, cladding, engraving, micromachining, 3D-prototyping);

The complex of ion-beam and plasma research facilities generating fluxes in the range from a few eV to 10^5 eV and power densities of up to 10 GW/m^2;

Linear electron accelerators with energy from 2 to 30 MeV, 2.5 MeV proton accelerator, ion sources, neutron generators.

Large technical resources and availability of unique equipment already enable wide range of research tasks in the field of critical technologies with high innovative potential:

- laser technologies based on energy-efficient fiber, disc, and hybrid lasers;

- materials research technologies for ultra-high temperature and pressure conditions (aerospace, nuclear technologies);
- technologies of new materials synthesis based on the resonant excitation of atoms and molecules by laser radiation that are inaccessible by other methods;
- new micro- and nanotechnologies for materials processing and creation of elements and mechatronics devices, electronics, and medicine;
- development of processing technology for the blades of gas turbine engines, and new heat-shielding materials;
- new methods of laser processing and modification of the superconducting current-carrying layers ensuring lossless power transmission;
- high-performance energy storage devices based on the new technology of laser-plasma modification of supercapacitors;
- compact (table-top) laser-plasma particle accelerators for proton therapy;
- development of radiation technologies involving accelerators;
- development of radiation technologies with high-power microwave fluxes.

High-power lasers, extreme light fields, environment-friendly energy production by the controlled nuclear fusion

Research and development in the fields of high-power lasers and ultra-intense light fields, plasma physics, extreme states of matter diagnostics, environment-friendly energy production by the controlled nuclear fusion are the strategic directions of the LAPLAS Institute activities.

Currently, a number of high-power laser facilities projects are being realized around the world. However, there is a shortage of laser facilities operating in kilojoule-energy level, the most relevant one for the extreme states of matter research. This is primarily due to uniqueness of the laser energy amplification technologies used in these facilities that are similar to the megajoule-level lasers. In order to carry out the research of the ultra-intense laser-matter interaction, in collaboration with Rosatom State Corporation and RAS institutes, in partnership with University of California, San Diego (USA), ECOLE Polytechnique (France), and Osaka University (Japan), the NRNU MEPhI-based Experimental Laser Physics Facility (ELF-MEPhI) is planned to be constructed. Since this facility is being created with orientation to the technological grounding of the Russian megajoule laser facility, many of its technological and design aspects will be used in ELF-MEPhI as well. The unique concept of high-power amplifier proposed for ELF has its competitive advantages. The amplifier scheme provides more than tenfold increase of the light intensity, enables extension of the laser complex functionality, and at the same time leads to 30% cost reduction of the facility and its

operating expense. The results of ELF-MEPhI project can be adopted by the Russian and international laser research facilities market through the commercialization of its technological features immediately after the laser facility commissioning and achieving the designed energy parameters.

Creation of the International Research and Education Center “International user Laser facility ELF-MEPhI” on the basis of the laser system will allow to establish the International Center of competences within the LAPLAS Institute and to carry out the innovative experimental studies, inaccessible to the majority of other facilities in the most relevant areas of modern physics:

- Laboratory astrophysics: energy and diagnostic capabilities of the system outperform the capacities of traditional kilojoule systems that will expand the range of experiments in this area, as compared with current activities.
- Laser fusion: generation of shock waves under the action of a laser pulse with a time shaped intensity, study of the equation of state of matter and the generation of soft X-ray radiation with respect to the exposure conditions in megajoule-level installations.
- Laser source of protons. The proposed laser complex will have sufficient power to produce beams of protons with energies up to 100 MeV. One of the most promising applications of the laser acceleration of protons is to create quasi-monoenergetic source with high intensity for oncologic therapy.
- Physics of shock waves. The energy parameters of the laser are sufficient for complex studies of phase and chemical transformations taking place in the material at pressures of a few hundred or more megabars (more than 10^8 atm).
- Creating a coherent source of ultraviolet and soft X-rays. Sources of UV and XUV radiation based on the effect of high harmonic laser generation are now widely used in the experiments, including attosecond optics. Advantages offered by the proposed laser system will allow achieving high degree of coherence and higher intensity UV and XUV radiation as compared with those obtained presently.

Optical information processing, radiophotonics, optical, laser, and quantum metrology

In the last decade, the traditional information technologies based on electronic engineering, have reached their physical and technical limitations, while the growth continued in consumer demand for speed and amount of transmitted information. A key solution to this problem was the union of the optical and information technologies. The first decade of the XXI century was characterized by rapid progress in the development and implementation of technologies based on photonics, namely radiophotonic systems, laser-optical information technologies, laser-optical measurements, laser-optical technologies for medicine and the life sciences.

Importance of the radiophotonics tasks (microwave photonics) is confirmed not only by the avalanche-like increase in the numbers of studies and publications observed since the beginning of this decade, but also by rapid (several times per year) growth of the market and the range of radiophotonic components and systems. Already at the present moment, radiophotonic systems have been used in solving communication problems and radiolocation. The most important applications include broadband analog communication via optical fiber, signal generation, beamforming, analog-to-digital conversion, and as a possible perspective — creating a digital radar. Currently, relevant practical needs are the establishment of broadband radiophotonic systems X, Ku, Ka, in the short term — the need to establish systems for radio signals in W range. As a near-term landmark problem, one can single out achievement of the effective accuracy of 10 bits for the signal bandwidth over 10 GHz in radiophotonic systems for various purposes.

Based on its considerable theoretical and experimental background, the LAPLAS Institute positions itself as a leading research center in the fields of radiophotonics, optical information processing, optical, laser, and quantum metrology. This activity is based on the developed integration ties with Russian and international research centers in the field of quantum metrology: VNIIFTRI, LPI, JIHT RAS, PTB (Germany), MPQ (Germany), and NIST (USA). LAPLAS Institute has following strategic directions of research in this field:

- radiophotonic broadband signal processing system
- precise laser and quantum measurements;
- laser cooling of atoms;
- optical, atomic, nuclear frequency and time standards;
- measurement of fundamental constants (the fine structure constant, the gravitational constant) and verification of the foundations of the cosmological effects of general relativity;
- quantum phenomena in solid state physics;
- remote detection of new oil and gas condensate deposits, deposits of rare earth elements on the basis of precise measurements with the use of highly stable frequency standards of the gravitational field of the Earth;
- remote environmental monitoring and cleaning of the environment using laser and plasma technologies.

Strategic partners of the LAPLAS Institute in the scope of its research activities are the leading centers and universities, such as:

Partner organizations	Field of partnership
IPG Photonics, Bauman Moscow State Technical University, National University of Science and Technology MISiS,	• Laser, plasma, radation, and beam technologies

Fraungofer Institute for Laser Technology (Germany)	
Russian Federal Nuclear Center – VNIIEF, Russian Federal Nuclear Center – VNIITF, Prokhorov General Physics Institute, Russian Academy of Sciences Lebedev Physical Institute of the Russian Academy of Sciences (LPI RAS) GSI Helmholtzzentrum für Schwerionenforschung (Germany) University of California, San Diego (USA) Ecole Polytechnique (France) University of Bordeaux (France) Osaka University (Japan) Universität Rostock (Germany)	• Laser physics, • High-power lasers, • High-power laser-matter interaction, • Extreme light fields, • Laser nuclear fusion, • Extreme states of matter and materials science.
State Research Center of Russian Federation Troitsk Institute for Innovation and Fusion Research, National Research Center "Kurchatov Institute", University of California, San Diego (USA) Forschungszentrum Jülich (Jülich Research Centre) (FZJ) (Germany), Max-Planck-Institut für Plasmaphysik (IPP) (Garching, Germany), CEA Institute for Magnetic Fusion Research (France)	• Controlled nuclear fusion, • High-temperature plasma and materials science.
Lebedev Physical Institute of the Russian Academy of Sciences (LPI RAS), All-Russian scientific research institute on physical engineering and radio engineering measurements (VNIIFTRI). Novosibirsk State University, Physikalisch-Technische Bundesanstalt (PTB) (Germany), Max-planck-institut für quantenoptik (MPQ) (Germany), National Institute of Standards and Technology (NIST) (USA)	• Laser physics and quantum metrology. • Radiophotonics • Optical data processing
Joint Institute for Nuclear Research National Research Center "Kurchatov Institute" (including ITEP and IHEP) Institute for Nuclear Research (INR) of the Russian Academy of Sciences, Skolkovo Cluster of Nuclear Technologies, CERN(Conseil Européen pour la Recherche Nucléaire*)* GSI Helmholtzzentrum für Schwerionenforschung (Germany) Belarusian State University	Accelerator engineering and radiation technologies
National Research Center «Kurchatov Institute», European Synchrotron Radiation Facility (ESRF) (France), Source Optimisée de Lumière d'Énergie Intermédiaire du LURE (SOLEIL) (France), Deutsches Elektronen-Synchrotron (DESY) (Germany).	Using synchrotron radiation

1. Target quantitative characteristics of the research activities of the LAPLAS Institute

Number of research projects carried out by the LAPLAS Institute in 2016–2018:

	unit	2016	2017	2018
Number of research projects, funded from the state	number	38	38	40

budget				
Number of research projects for industry	number	6	8	10
Number of research projects funded by the 5-100 Program	number	0	3	3
Number of applications for grants	number	20	25	30
Participation in international collaborations	number	4	6	7

V. International activities of the LAPLAS Institute

1. International cooperation

Currently, key international partners of the LAPLAS Institute are:

ITER (France)	Staff training, research and development of the edge plasma physics, its diagnostics and modeling
University of San Diego, California (USA)	Joint training, research, exchange of students and SEP, short-term mutual visits
Erasmus Mundus "International Doctoral College in Fusion Science and Engineering" (FUSION-DC)	Joint training of undergraduate and graduate students
CEA – Institute for Magnetic Fusion Research (France)	Joint research in the field of nuclear fusion, in particular, participation in the ITER project
Physikalisch-Technische Bundesanstalt (PTB) (Germany)	Cooperation in the field of quantum standards of time and frequency
Ghent University (Belgium)	Academic exchanges of SEP and students. Joint postgraduate advisement. Organization of joint events. Joint publications in the high-ranking scientific journals.
Turin University (Italy)	Joint postgraduate program
University of Bordeaux (France)	Joint research in the field of laser plasma physics

Number of agreements on international cooperation of the LAPLAS Institute in 2016–2018

	unit	2016	2017	2018
Number of agreements on international cooperation	number	18	22	28

2. Academic mobility of SEP

Due to the planned development of the international activities of the LAPLAS Institute and with the new agreements being prepared, the international mobility of Russian SEP will increase, leading to higher standards of education and promotion of the scientific research activities thanks to more energetic exchange of experience and competences, as well as through the involvement of Russian SEP in the competitive global environment.

Development of a healthy competitive environment will be aided by the development of platforms for collaborative experimentation and R&D on the basis of international laboratories and research and education centers that will attract the foreign colleagues to the LAPLAS Institute not only as invited lecturers, but also as scientists. Trend of the international mobility of the LAPLAS

Institute is shown in the table below:

International mobility of SEP	unit	2016	2017	2018
- inbound	person×month	4	6	8
- outbound	person	34	42	50

3. Academic mobility of students

LAPLAS Institute develops different academic mobility programs for Russian and for foreign undergraduate and postgraduate students.

Russian undergraduate and postgraduate students of the LAPLAS Institute regularly undergo training in the leading foreign research and educational centers. The obtained knowledge is then used to improve the quality of research by the participants of training, and the education quality — by postgraduate students.

At the same time, the LAPLAS Institute focuses its activities on involving foreign students in the full-time educational courses / modules as well as in the internships. In the framework of international schools and conferences regularly held by the LAPLAS Institute, the Institute's programs are advertised and promoted. Creation of international scientific and educational centers and initiated modernization of educational programs will increase the proportion of foreign students enrolled in the LAPLAS Institute in different modules and programs that will become one of the sources of financial stability and autonomy of the LAPLAS Institute.

International mobility of students	unit	2016	2017	2018
- outbound	person	70	100	150
- inbound	person	3	20	25

VI. Estimated budget of the LAPLAS Institute

Incoming part of the LAPLAS Institute budget in 2016−2018 is primarily formed by:

- - income from R&D activities;
- - income from educational activities;
- - state support through the 5-100 Program.

Maintaining high standards in educational activities through the launch of new programs and modules, including those demanded by industry, the LAPLAS Institute, however, makes a strategic bet on the income from the research activity.

The state support through the 5-100 Program will gradually decline, but it will help the Institute to form a strong R&D structure, where the International Research and Education Center "International user Laser facility ELF-MEPhI" might play the leading role. For the establishment and equipping of International Research and Education Center ELF-MEPhI, in the LAPLAS Institute expenditure part 410 million rubles are allocated to 2021.

It is expected that the strengthening of the research component of the LAPLAS Institute, including the impact of IREC ELF-MEPhI, will facilitate the short-term achieving of the financial stability due to the growth of revenues from industry-driven research, and from grants, both Russian, and, eventually, overseas.

Gradual increase in the revenue part of the LAPLAS Institute will enable an investing in human capital. The Institute, in its expenditure part, plans to increase spending on salaries of scientific and educational staff, including through the recruitment of a greater number of Russian and foreign high class specialists.

Thus, the financial plan of the LAPLAS Institute aims at developing of infrastructure projects that will help the Institute to make a qualitative leap in scientific research. This, in turn, will lead to a qualitative change in the educational component of LAPLAS activities and consequently to the financial stability and autonomy of the Institute.

	unit	2016	2017	2018
Incomings				
- educational activities (budget)	mln RUB	65	80	90
- educational activities (paid education)	mln RUB	1,2	3	5
- research (state order)	mln RUB	26	35	35
- research (industry)	mln RUB	71	180	250
- grants (Russia)	mln RUB	105	210	280
- grants (International)	mln RUB	0	0	5
- 5-100 Program	mln RUB	150	100	80
- other programs	mln RUB	0	0	0
- fees from the intellectual property	mln RUB	0	0	5

- Other incomings	mln RUB	0	0	0
Expenses				
- overhead university charges	mln RUB	44	98	132
- wages	mln RUB	165	200	210
- charges on payroll	mln RUB	49	61	64
- business trips	mln RUB	3	6	8
- procurement of equipment	mln RUB	36	160	220
- purchase of other fixed assets and other assets	mln RUB	0	30	10
events (conferences, seminars)	mln RUB	2	5	10
- other expenses	mln RUB	119	48	96

VII. Target performance indicators (reference)

	unit	2016	2017	2018
Position in THE rating “Physical Sciences”	-	1-100	1-100	1-100
Position in QS “Physics & Astronomy”	-	51-100	51-100	51-100
Number of publications in Web of Science per single SEP	number	9	9,7	10,2
Number of publications in Scopus per single SEP	number	10,3	10,9	11,5
Citing index per single SEP in Web of Science	number	43	47	52
Citing index per single SEP in Scopus	number	46	54	60
Fraction of international research staff in SEP	%	15,2	16	19
Fraction of international students	%	11	12	16
Mean high school score	-	>86	>86	>86
Share of income from non-budgetary sources	%	44	48	57
Proportion of undergraduates and graduate students with a degree from other universities	%	5	10	15
Amount of R&D per single SEP	thousand RUB	2210	2360	2470
Number of SAU educational programs with international accreditation	number	18	20	25
Number of SAU educational programs fully available in a foreign language	number	5	8	11
Number of educational programs for double diplomas	number	5	7	10
Fraction of SAU students engaged in R&D in SAU	%	35	45	45
Fraction of MEPhI students studying in SAU	%	6,9	7	7
-the same for the undergraduate courses (specialist courses)	%	5,3	5,3	5
-the same for the master courses	%	9	9	9
-the same for the postgraduate courses	%	16	16	16
Fraction of SAU SEP authoring publications in Scopus or WoS	%	100	100	100
Share of SAU employees in the total number of MEPhI employees	%	5,4	5,4	5,6
Amount of registered intellectual property	number	9	10	15
Mean SNIP of Scopus journals where the papers of SAU SEP are published	-	0,9	1	1,5