

# Project Report

## **“Development of an open educational environment to support research priorities in materials sciences and structure of matter”**

Theme reference No.: 06-0-1120 -2014/2018, 06-0-1139-2019/2023

### **ABSTRACT**

According to main topics of the project development there were obtained the following results:

#### **I. Online courses and new educational programs within the subject-matter of JINR projects on the basis of modern educational platforms**

*This part of the project was realized through the creation of JINR open educational portal ([edu.jinr.ru](http://edu.jinr.ru)) with online-courses, interactive multimedia educational resources for university and school students.*

#### **II. Multimedia educational resources for websites of JINR laboratories**

*This part of the project was realized through:*

- *support of the official web-sites of Frank Laboratory of Neutron Physics and Polish Group in JINR;*
- *creation of the web-site of IBR-2 User Club;*
- *creation and support of the official web-site of NICA megaproject,*
- *renovation of NRV (Nuclear Reaction Video) Open Web Oriented Platform;*
- *creation of videos about main activities of the Laboratory of Neutron Physics for the basic departments of the FLNP*

#### **III. Informational and educational support of NICA megaproject**

*This part of the project was realized through multimedia resources and an online course “Megascience project NICA” (Russian and English versions), that consist of following sections:*

- *Megascience projects*
- *Particle accelerators at JINR*
- *Structure and tasks of NICA complex*
- *Injection complex*
- *Superconducting magnets*
- *Nuclotron*
- *Collider*
- *Cryogenic complex*

#### **IV. Multimedia exhibits related to JINR subject-matter**

*This part of the project was realized through:*

- *Creation of multimedia stands in JINR Visit Centre*
- *Creation of multimedia exposition in JINR Science and Technology Museum*

- *Participation in creation of multimedia exposition in JINR Informational Centre in the South of Russia (North Ossetian State University, Vladikavkaz)*
- *Multimedia exposition at the International Festival of Science and Education 2018 (Novi Sad, Serbia)*
- *Interactive JINR expositions during events in Egypt, Serbia, Vietnam, and Russia*
- *Exposition “JINR Main Facilities” at the International Symposium on Exotic Nuclei (EXON) in Kazan (2017), Petrozavodsk (2018), Dubna (2019)*
- *Exposition “Megascience project: NICA” at XIX World Festival of Youth and Students (Sochi, Russia)*

## **V. Educational web resource “Virtual Laboratory of Nuclear Physics”**

*This part of the project was realized through:*

- *creation of distant course: “Introduction to Experimental Nuclear Physics”;*
- *creation of 3 new sections:*
  - *“Laboratory of Gamma Spectrometry”,*
  - *“Laboratory of Detectors and Data Processing”,*
  - *“Laboratory of Data Analysis in ROOT”;*
- *development of the web-site of the project “Virtual Laboratory of Nuclear Fission”;*
- *development and organization of hands-on practicums on experimental nuclear physics for university and school students;*
- *development of methodological materials for student practices;*
- *organization of off-site workshops on experimental nuclear physics for university students;*
- *organization of workshops with project participants from Russia, Bulgaria, Serbia, South Africa.*

## **VI. Educational materials for teachers and school students**

*In the framework of the project the following multimedia educational resources have been developed:*

### *1. Videlectures “NICA – the Universe in the Lab” (Russian and English versions):*

- *Introduction*
- *The Universe had a beginning*
- *Quark-gluon plasma*
- *Tools helping us look into the heart of matter*
- *Accelerator complex NICA*
- *Complex NICA and progress of technology*
- *New discoveries at NICA are waiting for you!*

*On the base of these materials open lessons for school and university students, workshops for physics teachers were held in schools and universities of Russia.*

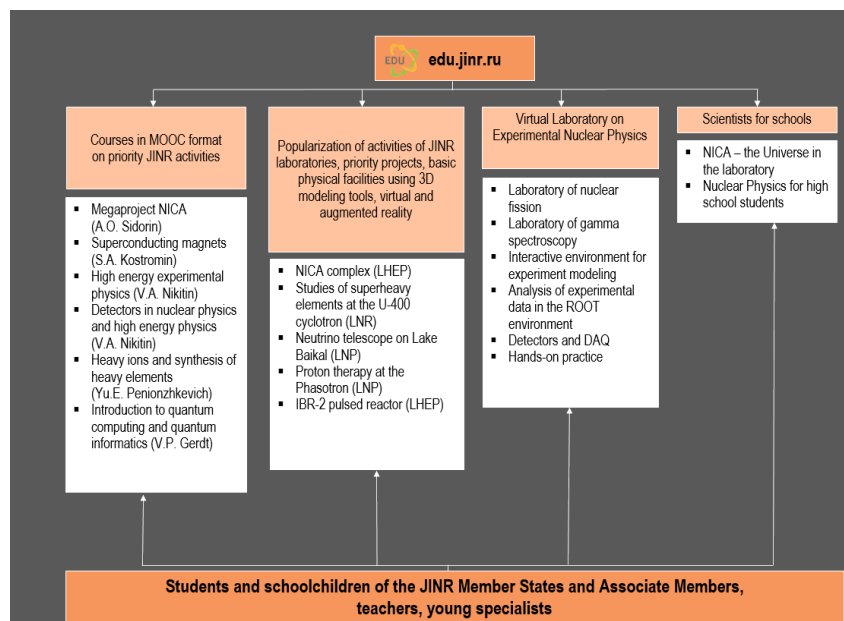
*2. A course of nuclear physics was developed and published at the Publishing House “Prosveschenie” for grades 10–11 of Russian schools. When creating the course, along with the traditional text-book, the course includes elements of augmented reality, video lectures, interactive tests, and a virtual laboratory practicum. The course contains the section “In the Laboratories of Scientists” on the JINR scientific topics.*

*In the framework of the project, in 2017–2019, 12 publications and 13 reports were prepared at international conferences and schools, 10 student practices were organized, more than 10 reports on events for physics teachers were presented, 2 bachelor's and 4 master's theses were prepared, and two candidate dissertations are being prepared.*

# I. Online courses and new educational programs within the subject-matter of JINR projects on the basis of modern educational platforms

The JINR open educational portal consists of four sections:

- “Online courses” in MOOC format on priority JINR activities;
- “Multimedia resources” using the capabilities of 3D modeling and augmented reality, which popularize experiments conducted in JINR laboratories;
- “Virtual Laboratory on Experimental Nuclear Physics”;
- “Scientists to schools”.



*Structure of the JINR educational portal*

The arguments for choosing such a structure and the results of the creation and development of JINR educational portal are given below.

## 1. Using of online courses for training specialists for research centers

In the past few years, people often talk about the “revolution in education,” which was accomplished by the massive open educational resources that appeared in 2014. Over the past few years, the number of students studying at MOOC platforms, the number of new online courses, and the number of new platforms has grown rapidly and continue to grow. According to the Class Central resource for 2018, the total number of MOOC students worldwide reached 100 million, and by the end of the year, more than 900 universities around the world announced the launch or opening of 11.4 thousands of MOOCs.

The world's most popular MOOC platforms publish online courses of experts from leading universities, or courses developed in collaboration with universities and their business partners. At the same time, an analysis of existing courses shows that among them there are quite a few courses devoted to the topics and problems of modern physical experiments developed by scientists and specialists directly involved in these experiments. Therefore, the task of creating online courses from leading JINR specialists dedicated to various aspects of priority research conducted at this international scientific center seems relevant.

JINR educational resource is able to help solve the following problems:

- popularization of modern scientific research, achievements in science and technology,
- increasing the attractiveness of scientific and scientific-technical careers for students and graduates,
- attracting young scientists and specialists to participate in specific research projects,
- professional development of school and university teachers,
- possibility to include materials related to modern achievements in science and technology in traditional educational courses.

The choice of topics for the online courses being developed at JINR is determined primarily by the need for young specialists to work at the Accelerator complex NICA (Nuclotron-based Ion Collider fAcility), in experiments on the synthesis of new superheavy elements (SHE Factory), in research in the field of the physics of condensed state of matter and environmental science carried out at a high-resolution neutron source IBR-2, in Deep-water Baikal Neutrino Telescope experiment and computing for megaprojects. Working in these and other experiments, students need to gain additional knowledge in the following areas:

- experimental physics,
- accelerator physics and technology,
- distributed computing and working with big data,
- cryogenic technique,
- biomedical physics,
- radiation material science,
- radiobiology,
- use of heavy ions, neutrons and synchrotron light in applied research.

Of course, online courses on these topics can hardly be widespread – a relatively small number of students need them. Nevertheless, these courses can play an important role in training specialists for modern research centers. The same courses can be useful for remote student trainings for various universities, if these universities do not have enough specialists of this profile.

## **2. Online courses at JINR open educational portal**

The first 8 online courses in Russian and English have already been created. They are:

- “Megaproject NICA” (A.O. Sidorin),
- “Superconducting magnets” (S.A. Kostromin, A.V. Konstantinov),
- “Experimental high-energy physics” (V.A. Nikitin),
- “Detectors in nuclear physics and high-energy physics” (V.A. Nikitin),
- “Heavy ions: fundamental and applied researches” (Yu.E. Penionzhkevich),
- “Basics of quantum computing and quantum informatics”(V.P. Herdt),
- “Gauge field theories on a lattice (V. Braguta, A. Kotov),
- “Radiation safety” (G.N. Timoshenko)

At present time several online courses are under construction, and there are agreements with leading experts from various JINR laboratories on recording new educational courses.



*Online courses published at JINR open educational portal*

The team of specialists working on the creation of online courses and interactive multimedia educational resources includes specialists of various profiles: content developers, computer methodologists, editors, designers and programmers. Moreover, in conditions of high competition and increasing quality requirements for digital educational materials, it is necessary to use the widest range of modern information technologies.



*Information technologies used to create online courses and interactive multimedia educational resources*

JINR specialists, representatives of universities of JINR Member States and Associate Members, and representatives of the basic departments of JINR University Centre expressed their desire to create educational content for online courses.

To organize the learning process, the MOODLE learning management system was deployed on the portal. The system of organization of the educational process (LMS) allows you to organize remote work of a teacher from JINR University Centre (UC) with students of the base departments of the UC at their universities. Using the system capabilities, the following tasks are easily solved:

- learning planning;
- role distribution;
- organization of knowledge and competency testing;
- opportunities for various training material support;
- user interaction opportunities in the system.

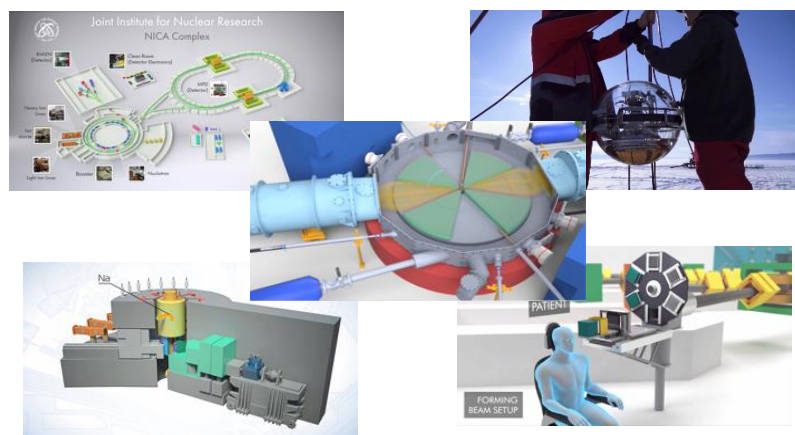
### **3. Multimedia resources, with use of opportunities of 3D modeling and augmented reality, popularizing experiments carried out in JINR laboratories**

In recent years, authors have been developing multimedia educational resources using the opportunities of 3D modeling and augmented reality, popularizing experiments conducted at JINR laboratories. These resources are used in organizing various events, such as student schools and

practices, exhibitions and open door days. There is a special section dedicated to such resources on JINR educational portal, which currently presents educational modules about NICA collider, IBR-2 reactor, the synthesis of new superheavy elements and SHE Factory, Baikal neutrino experiment.

Great interest in these resources is shown by physics teachers participating in annual international schools for teachers, which take place in Dubna and CERN. Since all modules are freely available, teachers can use them in physics classes, or when conducting specialized classes and electives, with an explanation of the relevant topics.

The developed models help clarify the operation of a particular facility.



*Multimedia resources about JINR basic facilities*

#### **4. Scientists for School**

The mission of any major scientific center along with scientific research is to solve a wide range of educational problems. Since the system of school and university education is very conservative, it is scientific centers that can become an objective source of knowledge about the latest achievements in science and technology.

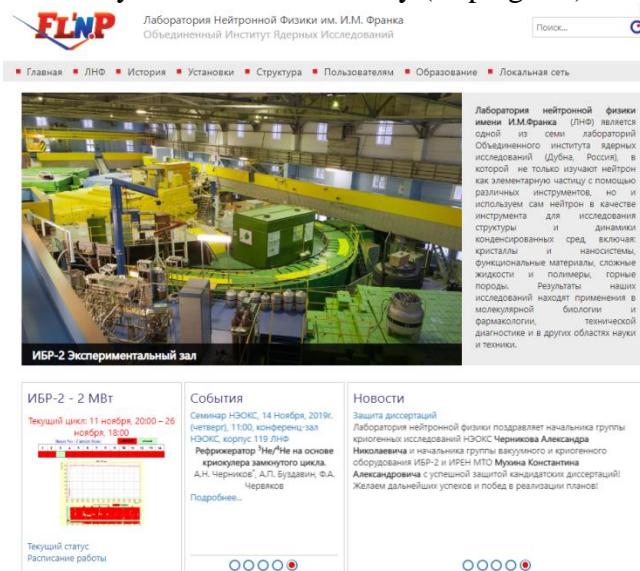
Another example of such a multimedia educational resource is the lesson for school students “NICA — The Universe in the Lab”, located in the section “Scientists for Students”. The lesson was based on a lecture given by academician G.V. Trubnikov.

JINR Educational Portal also contains digital educational materials for the elective course “Nuclear Physics”.

## II. Multimedia educational resources for websites of JINR laboratories

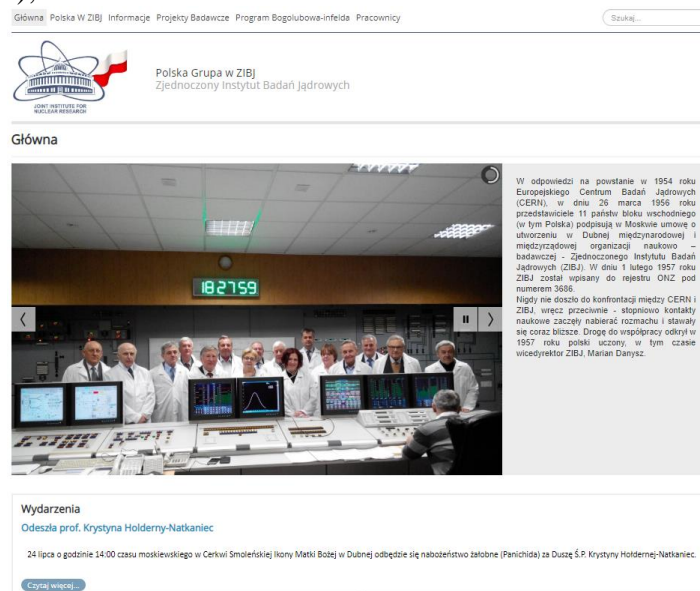
As part of the project, **in collaboration with the Frank Laboratory of Neutron Physics (FLNP)** for the reporting period, the following work was performed:

- **in 2017:**
  - support of the official website of Frank Laboratory of Neutron Physics ([flnph.jinr.ru](http://flnph.jinr.ru)), as well as the information system of the laboratory ([flnp.1gb.ru](http://flnp.1gb.ru)).



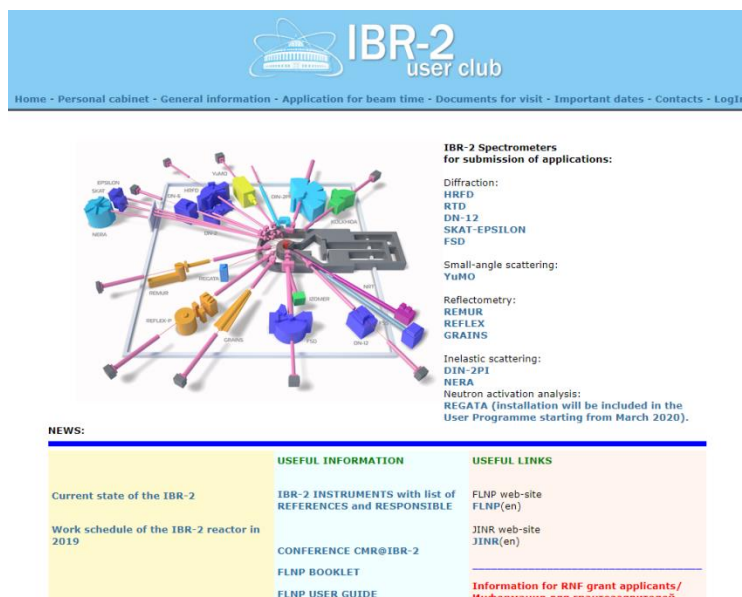
*The mainpage of the official website of FLNP (<http://flnph.jinr.ru/ru/>)*

- **in 2018:**
  - support of the official website of the Polish group of the Joint Institute for Nuclear Research ([poland.jinr.ru](http://poland.jinr.ru));



*The mainpage of the official website of JINR Polish group ([poland.jinr.ru](http://poland.jinr.ru))*

- **in 2019:**
  - creation of the User Club system of IBR-2 reactor for the formation and processing of online applications based on the website <http://ibr-2.jinr.ru/> of Frank Laboratory of Neutron Physics;



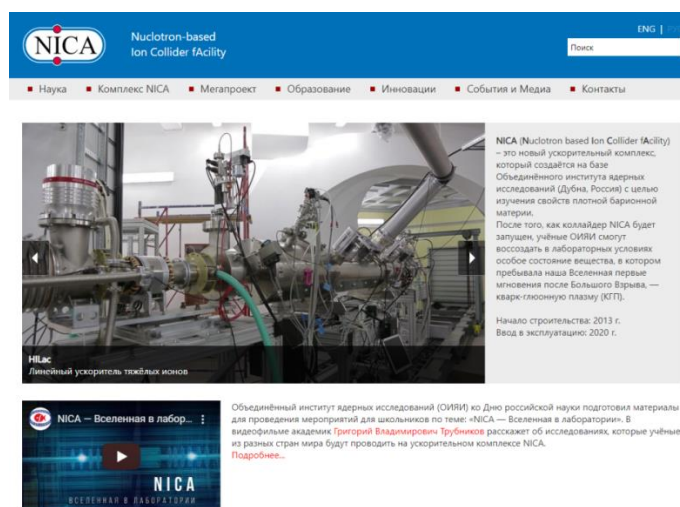
*The main page of the User Club system of IBR-2 reactor (<http://ibr-2.jinr.ru/>)*

- creation of four videos about the main activities of Frank Laboratory of Neutron Physics for the basic departments of FLNP using combination of three-dimensional animation and live video shooting.



*Video fragments about the main activities of Frank Laboratory of Neutron Physics*

As part of the project, **in collaboration with Veksler and Baldin Laboratory of High Energy Physics (LHEP)** the website of NICA megaproject was developed and has been supported by the project team.



*The main webpage of NICA megaproject*

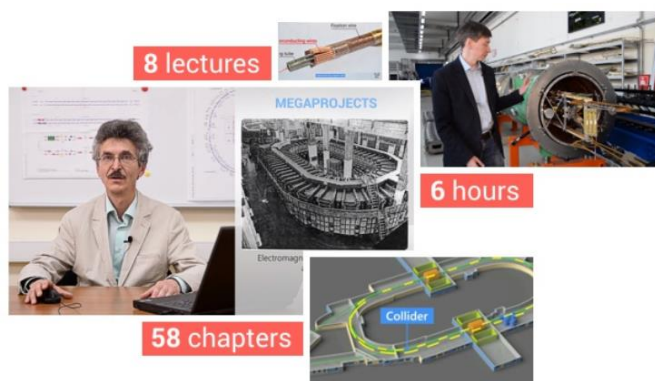
### III. Informational and educational support of NICA megaproject

Educational support of the megaproject NICA is aimed at attracting public attention (school and university students and generally interested audience) to the scientific achievements of JINR and also training specialists to work at the accelerating complex NICA in the mid-term and long-term perspective.

It is also necessary to include scientific and applied results obtained at NICA in the educational programs of undergraduate and postgraduate education. The expected scientific results obtained at NICA collider will undoubtedly broaden the horizons of the world's knowledge about the structure and evolution of matter at the early stage of the Universe evolution and, in the light of experimental data, will allow one to answer the actual questions of the modern science, for example about nucleon spin nature and spin structure of the lightest nucleus – deuterium – at small distances. Such scientific findings and technological solutions should be accompanied by educational, popular-science and outreach projects intended for a wider audience, including school students. In the future, it will allow us to overcome a serious social problem – decline in young people's interest in scientific research and engineering professions.

Creation of a modern educational environment of continuous learning and training of highly qualified personnel in the framework of the mega-project “NICA complex” requires development of online courses within NICA project subject-matter, for example, about basics of accelerator equipment, experimental methods of nuclear physics, introduction to the physics of relativistic nuclear collisions, electronics for physics experiment etc.

The special attention will be paid to the development and promotion of the specialized site of the NICA project which will include as the actual project information as educational materials within the subject-matter of NICA project for students and young scientists. Using modern technologies of 3D-modeling and scientific data visualization will enable the development of educational resources of NICA at the level of the world's leading research centers. The interactive map of NICA complex was created and will be updated during the development of the complex. Interactive map allows you to learn the setups of the collider. Complete modules of the complex shot on video, in order to demonstrate the current construction process. The modules, which are at the stage of development now demonstrated as a 3-D graphics that reveal the device itself and explain it's working principle. For each node of the complex we are expecting to make both video and graphic materials.



*Online course “Megascience project NICA”*

## IV. Multimedia exhibits related to the JINR subject-matter

Modern world is a world of high technologies and amazing science discoveries. To give young people an opportunity to learn about modern worldview, complex technical equipment and prepare the most talented ones to future science and engineer career is task not only for schools and universities but for science laboratories as well. That's why the Joint Institute for Nuclear Research pays much attention to the creation of multimedia expositions devoted to the main activities of JINR.

These expositions were designed for school and university students, science teachers, the general public who are interested in physics, biology, ecology, chemistry and nanotechnologies.

In 2017–2019 our team took place in organization of the following expositions:

- multimedia stands in JINR Visit Centre;
- multimedia exposition in JINR Science and Technology Museum;
- multimedia exposition at JINR Info-Centre Opening Event in North Ossetian State University (Vladikavkaz, Russia), October 12, 2018;
- exposition “JINR Main Facilities” at the International Symposium on Exotic Nuclei (EXON) in Kazan (2017), Petrozavodsk (2018), Dubna (2019);
- interactive exposition “JINR Main Facilities” dedicated to the 10-th Anniversary of JINR–Serbia Cooperation, EXPO-RUSSIA (Belgrade, Serbia), March 15–18 2017;
- exposition “Megascience project: NICA” at XIX World Festival of Youth and Students (Sochi, Russia), October 14–22, 2017;
- exposition “JINR Main Facilities” and “Virtual Lab” at EXPO-RUSSIA (Hanoi, Vietnam), December 13–15, 2017;
- exposition “JINR Main Facilities” at 14th Arab Conference on the Peaceful Uses of Atomic Energy (Sharm El Sheikh, Egypt), 16–20 December, 2018.



*JINR multimedia expositions*

## V. Educational resource “Virtual Laboratory of Nuclear Physics”

Experiments have always been an integral part of the experimental sciences, such as Physics, and are one of the most effective ways to get first-hand knowledge about certain concepts and principles in a study field such as nuclear physics. It is challenging for some universities to set up an excellent practicum on nuclear physics, because they do not have enough equipment available. Moreover, it would be interesting to hold a practicum on nuclear physics for high school students specializing in physics and mathematics, but the schools do not have the appropriate equipment or teachers trained for it.

The Virtual Lab project (VLab) has a history of several years. The result of the first phase of this project was the Virtual Laboratory of Nuclear Fission.

The aim of this project was to create a hardware-software complex for training specialists for LIS experiment (Light Ion Spectrometer), conducted at JINR Laboratory of Nuclear Reactions to study spontaneous fission. The Virtual Laboratory of Nuclear Fission includes educational materials and virtual practicums as on the basics of working with nuclear physics equipment (oscilloscopes, detectors, data acquisition system), as on the basics of working with real experimental data obtained from LIS setup.



*Virtual laboratory project. Present status*

An Interactive Environment for Nuclear Experiment Modeling was developed. Working in this environment, students can assemble a personal experimental setup from elements of virtual nuclear physical equipment contained in the libraries of the environment. Also in the environment there is a library of radioactive sources for conducting your own experiment. For advanced students with programming skills there is the opportunity to develop their own virtual radioactive sources, detectors, blocks of electronics, etc. and integrate them into the environment.

On the basis of the Interactive Environment for Nuclear Experiment Modeling students of Dubna University completed 2 graduate qualification bachelor works. In one of the works, a virtual radioactive source (radium-226) was simulated, and in another, some elements for the libraries of detectors and electronics of a nuclear physical experiment were developed.

Testing the project showed the need to develop additional materials that allow the student to fill the lack of knowledge to complete a virtual laboratory work, without going beyond the scope of the project. Therefore, open courses on experimental nuclear physics were developed for students with different levels of basic training.

Now all these results are used in the educational process universities in 16 countries.

Currently the project is developing in four directions: 1. Virtual laboratory of gamma spectroscopy; 2. Laboratory of detectors and signal processing. 3. Laboratory of data analysis in ROOT; 4. Preparation and conduction of hands-on practicums for university and high school students.

When working with real data, various problems and challenges arise. Before getting physical results, when working with real data, researchers need, on the one hand, to perform a series of calibrations, to separate the useful signal from the background, etc., and on the other hand, to take into account the specific features of an experimental setup. The Laboratory of detectors and data processing and the Laboratory of data analysis in ROOT are aimed at forming of these skills.

#### **4. Preparation and conduct of hands-on practicums for university and high school students**

In the framework of the VLab project several hands-on practices were successfully held for university and high school students from different countries. During the practices students started their work with signal generators, oscilloscopes, coincidence circuits, scintillation counters, and finished assembling a simple scintillation telescope that allowed them to register cosmic radiation particles. Then, under supervision of young scientists, students worked with gamma-, X-ray and light ion spectrometers. Attention was given to the analysis of experimental data.

Over the past few years, the specialists of the Virtual Laboratory project have participated in organizing and conducting the following three-week practices for university students of the participating countries and associate members of JINR Member States and Associate Members:

- September Student Practice 2014 at JINR (III stage)
- September Student Practice 2015 at JINR (III stage)
- July Student Practice 2017 at JINR (I stage)
- September Student Practice 2017 at JINR (III stage)

The hands-on practice program has been adapted for high school students. Recently, 4 hands-on practices have been organized for students from Israel (2018, 2019), the Czech Republic (2019) and Germany (2019). In these practices students participated with their physics teachers. The lectures and workshops were so successful that school teachers expressed a desire to take their new students to these practices next year.



*High school students from Israel assembling the vacuum system*

For this practicum methodological resources were used, which include step-by-step instructions that guide the students to achieve the results needed, pictures of expected outcomes and opportunities were created to help students write their conclusions.

## VI. Educational materials for teachers and school students

The implementation of international modern research projects makes an invaluable contribution into such the fundamentally important problem as the raise of educational and cultural awareness of people. Educational support of such projects is aimed to attract public attention (school and university students, science teachers and generally interested audience) to the scientific achievements. The use of modern multimedia and communication technologies for the development of projects related to the science popularization opens up wide opportunities for explaining complicated things in a clear and understandable form.

Modern scientific findings and technological solutions should be accompanied by educational, popular-science and outreach projects intended for a wider audience, including school students. In the future, it will allow us to overcome a serious social problem – decline in young people's interest in scientific research and engineering professions.

In 2017 the online-lesson for school students on the topic: “NICA – Universe in the Lab” was produced. In this video, Academician Grigory Trubnikov speaks about the research that scientists from different countries will carry out at the NICA accelerator complex. This is an education material for school students and science teachers, which we tried to do interesting for all ages. It’s a popular science movie, where we talk about the role of science in our life, how our Universe was created, about phase transitions of matter and quark-gluon plasma etc. We explain why do we need particle accelerators and colliders and how they work.

Our experience of public presentations and workshops shows that teachers and school students take great interest in our multimedia presentations.

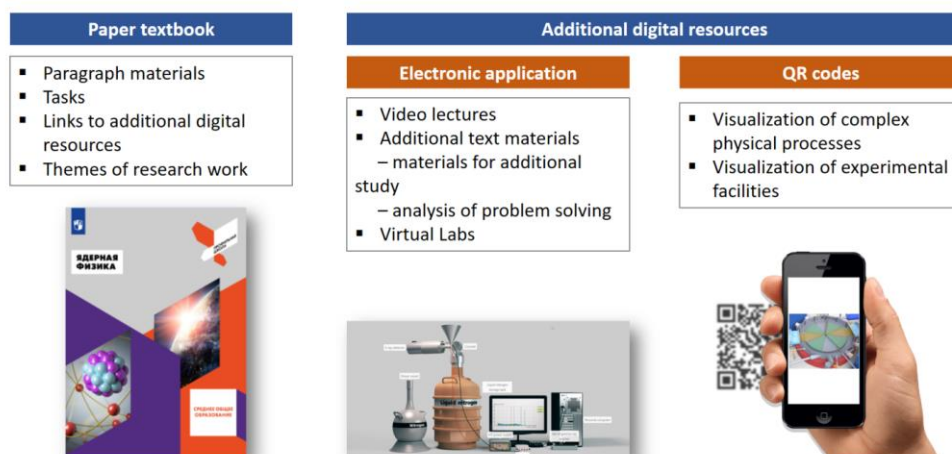


*Presentation of the open online-lesson “NICA – Universe in the Lab” in Petrozavodsk State University*

On the base of these materials open lessons for school and university students, workshops for physics teachers were held in schools and universities of Russia. The site with educational materials “NICA – Universe in the Lab” was visited by representatives of more than 60 regions of Russia.

2. A course of nuclear physics was developed and published at the Publishing House “Prosvetshenie” for grades 10–11 of Russian schools. When creating the course, along with the traditional text-book, the course includes elements of augmented reality, video lectures, interactive tests, and a virtual laboratory practicum. The course contains the section “In the Laboratories of Scientists” on the JINR scientific topics.

Over the past year, an elective course “Nuclear Physics” was developed for high school students, including a traditional paper textbook, an electronic application and an illustrative series available on mobile devices using QR codes.



### Materials of the course “Nuclear Physics”

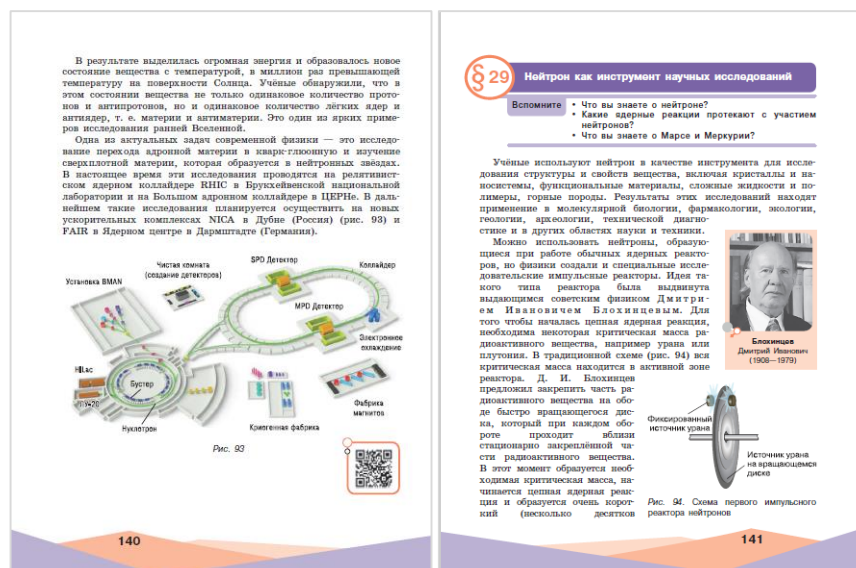
The main idea of the course can be formulated as “From Nuclear Physics to Nuclear Technologies”. Starting with a fairly simple material, such as alpha, beta and gamma decays, the authors are moving towards the application of the laws of nuclear physics and the modern scientific research.

Each chapter in the textbook provides links to additional digital materials:

- video lectures,
- examples of problem solving,
- additional materials for advanced study.

At the end of the textbook you can also find the references to a virtual practicum on nuclear physics, final testing, and approximate research and project works.

The textbook pays special attention to the modern achievements of nuclear physics. It tells about modern international experiments conducted at JINR and other international scientific centers.



### Double-page spread of the textbook

In the framework of the project, in 2017–2019, 12 publications and 13 reports were prepared at international conferences and schools, 10 student practices were organized, more than 10 reports on events for physics teachers were presented, 2 bachelor's and 4 master's theses were prepared, and two candidate dissertations are being prepared.

## **Participation in International events: student practices, JINR Expertise for Member States and Partner Countries, exhibitions**

1. July Student Practice 2017 at JINR (I stage), JINR, Dubna, Russia.
2. September Student Practice 2017 at JINR (III stage), JINR, Dubna, Russia.
3. Practice for high-school students from Israel 2018, JINR, Dubna, Russia.
4. Practice for high-school students from Israel 2019, JINR, Dubna, Russia.
5. Practice for high-school students from the Czech Republic 2019, JINR, Dubna, Russia.
6. Practice for high-school students from Germany 2019, JINR, Dubna, Russia.
7. International training programme for decision-makers in science and international scientific cooperation JEMS – «JINR Expertise for Member States and Partner Countries» – 2017–2019, JINR, Dubna, Russia.
8. IV International Industrial Exhibition EXPO-RUSSIA SERBIA 2017, 14–18 March 2017, Belgrade, Serbia.
9. XIX World Festival of Youth and Students (Sochi, Russia), October 14–22, 2017.
10. 2nd Industrial Exhibition “EXPO-RUSSIA VIETNAM 2017”, 13–15 December 2017, Hanoi, Vietnam.
11. 16th Arab Conference on the Peaceful Uses of Atomic Energy, 16–20 December 2018, Sharm El-Sheikh city, Egypt.

## Reports to International Conferences

1. International Scientific – Practical Conference «Information Innovative Technologies, 2017» (Prague, Czech Republic), April 24–28 2017
2. JINR days in Poland, Jagiellonian University (Krakow, Poland), May 24, 2017
3. Scientific School for teachers of physics at JINR, Dubna, 26 June – 1 July 2017.
4. the 10th Anniversary International School for Nuclear Physics “JINR Days in Bulgaria”. 16–19 May 2017. “Borovets” mountain complex, Sofia, Bulgaria.
5. The 14th annual international Conference on Hands-on Science: Growing with Science, HSCI2017. July 10–14, 2017. Braga, Portugal.
6. Workshop for VLab collaboration, June 30 –July 10 2017, Stellenbosch, South Africa.
7. 26-th International Symposium on Nuclear Electronics & Computing (NEC’2017), 25-29 September 2017. Montenegro, Budva, Becici.
8. International Festival of Science and Education 2018 (Novi Sad, Serbia), May 13, 2018
9. The 15th annual international conference on Hands-on Science, HSCI2018, The Hands-on Science Network ([www.hsci.info](http://www.hsci.info)), Barcelona, Catalonia, Spain, 16 – 20 July 2018.
10. IX International Symposium on EXOtic Nuclei (EXON-2018), 10–15 September 2018 Petrozavodsk, Russia.
11. South Africa-JINR Workshop “Virtual laboratory on detectors and signal processing” Somerset West, South Africa, 26 October – 04 November, 2018.
12. 5th Symposium «Advances and Challenges in Physics by JINR and South Africa», 4–9 November 2018. Somerset West, RSA.
13. Scientific school for physics teachers from the Czech Republic and Slovakia, 1–5 June 2019. JINR Laboratories, Dubna, Russia.
14. JINR–DSU Summer School “Physics.Mathematics.Informatics”. 14–24 July 2019, Dubna, Russia.
15. XXVII International Symposium on Nuclear Electronics & Computing, Montenegro, Budva, Becici, 30 September – 4 October 2019.
16. XII regular Scientific School for teachers of physics from the JINR Member States at CERN, 3–10 November 2019, CERN, Geneva, Switzerland.

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