

Project Report

“Development of modern education programmes”

Theme reference No.: 06-0-1120 -2014/2018

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

I. Optical Laboratory

Investigation of matter structure and simple biological structures. Team laboratory research for pupils and undergraduate students using the network environment of collective modeling.

This part of the project was realized in the Dubna Education Center named after Academician A.N. Sissakian

II. Virtual Laboratory of electron microscopy

Interactive models of various types of electron microscopes (transmission, scanning, scanning transmission, scanning tunneling). Experimental methods of electron microscopy. Laboratory work on the study of the structure of micro and nano objects based on the use of augmented reality technologies.

This part of the project was realized as hardware and software complex “Microskopes” that is Virtual Laboratory of electron microscopy. Complex was demonstrated at different international exhibitions and was presented as master classes for teachers in Hands On Science Conference.

III. Probe Microscopy Laboratory

Construction of the probe microscopy laboratory on the basis of multifunctional scanning probe microscope with full Internet control. Development of laboratory work package allowing implementation of various modes of scanning probe microscopy.

The key financial resources related to the acquisition of equipment for the project will be used to establish a laboratory of the probe microscopy.

This part of the project have been not supported of financial resources.

IV. Interactive model of the accelerator complex for relativistic nuclei

Creation of accelerator complex interactive model for research in particle physics and relativistic nuclei in the network environment of collective modeling.

Interactive elements of the model explain the basic principles of accelerator physics, motion of particles in magnetic fields, accelerating systems, principles of strong focusing, principle of phase stability, stochastic cooling beams, etc.

- *It is developed the interactive multimedia model of NICA complex (nica.jinr.ru)*
- *There were developed the interactive multimedia models the main facilities at JINR (<https://www.youtube.com/channel/UC2JqWjHiVb3Tw-AaLTu1u5A>)*

V. Study of nucleus-nucleus collisions at the collider

A new type of laboratory-based works for students and pupils using STAR installation experimental data obtained in a wide range of energies in the experiments at the relativistic nuclei collider is proposed. In order to conduct the laboratory works it is planned to develop a multimedia interactive electronic textbook on the methods of experimental research at an existing physical facility, and to prepare a set of abridged laboratory works based on real experimental data for school and university audiences.

It is designed the web-resource "Nuclear Science and Technology" (<http://nsww.org/>). Interactive models of detectors STAR (BNL) and MPD (NICA) were developed based on

WebJL technologies (3D interactive graphics). Virtual labs based on real experimental data on gold-gold collision: "Measurement of proton and antiproton yields in the central collisions at RHIC energies" was realized. These results were presented on the Physics Teachers School as resources for teaching physics in a classroom.

VI. Interactive model of synchrotron light source

Creation of interactive model of the experimental complex in the network environment of collective modeling for studies of photon beam in a wide range of energies. The model includes virtual implementation of the basic units.

This part of the project was realized as a unit of software complex "Microscopes". Since during the project realization the main attention was paid to the JINR basic facilities (IBR-2, NICA, SHI-Factory, MTK, Neutrino Physics), topics related to photonic physics were reduced.

VII. Laboratory workshop on accelerator equipment

It is planned to create laboratory workshop on the basis of Dubna linear accelerator of electrons and undulator-based free electron laser. It is planned to create a virtual interactive model of linear accelerator and free electron laser and to join up video streams from the remote control of the complex, video cameras and detectors monitoring passage of the electron beam and synchrotron light in the undulator to this model. This can be done in real time during operation of the accelerator.

Due to the highest priority of this job it was organized the special engineering department at UC JINR that leads works on training of accelerator specialists.

Additionally over the past 4 years the project participants have taken part in the development of the following educational, popular-science and outreach resources:

1. multimedia exhibits popularizing modern science presented at the world's leading sites
2. Dubna Education Center named after Academician A.N. Sissakian. Participation in the educational program "School for Russian Physics Teachers"
3. project "Virtual Laboratory of Nuclear Fission"
4. nuclear physics online courses for MOOCs Coursera and edX intended for university students and developed in collaboration with MEPhI

1. Multimedia presentations and exhibitions, popularizing modern science, presented at the world's leading sites

Multimedia exhibition "Main Facilities at JINR"

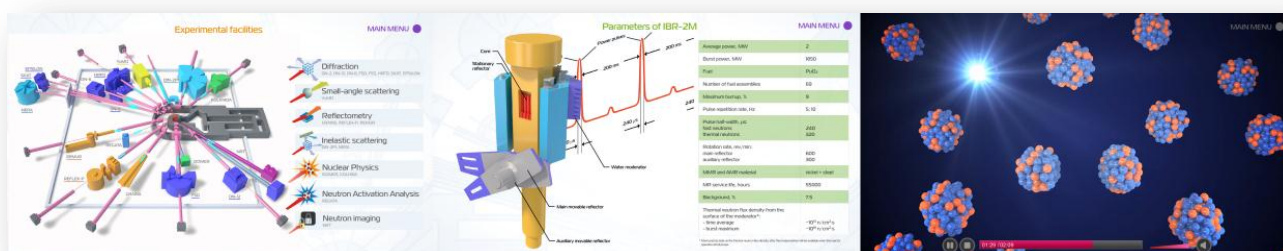
The project is aimed at promoting scientific achievements of the Joint Institute for Nuclear Research to a wider audience (for those who is familiar and unfamiliar with nuclear physics — pupils, students, adults) and attracting young people to work at JINR. This project can be represented both at the popular science exhibitions and at the events associated with JINR activities. The exposition combines interactive 2-D, 3-D graphics and real videos of the JINR setups, which demonstrates the principles of operation and purposes of the institute facilities. At the moment they are:

- NICA Complex
- Superheavy elements factory
- Neutrino telescope at Lake Baikal
- Medico-Technical Complex
- IBR-2 Reactor

Special attention is allocated to a NICA project as the JINR flagship project nowadays. The interactive map of the 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.

Multimedia exhibition "Main Facilities at JINR" was successfully presented at the events dedicated to the JINR 60th Anniversary in Armenia, in the technical museums of Slovakia, on the Anniversary celebration in Dubna, in the frame of the EXON'2016 Event (Kazan), NAUKA0+ Festival in MSU and Expocentre (Moscow), also during the 10th Anniversary of the SAR-JINR cooperation and Science Forum South Africa (SAR, Pretoria). We are planning the constant expansion and the development of this project.

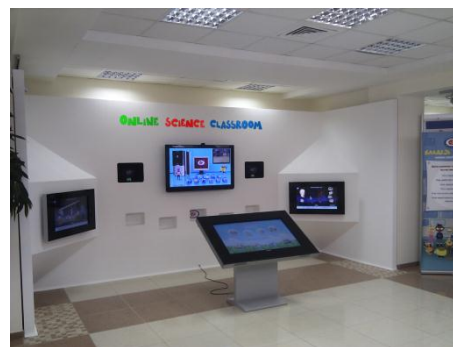
Also at the same time we a working on the popular-science lesson for school students "NICA. The Universe in the Lab" for NICA project propaganda in the Russian Federation. We've created and now developing the official website of the NICA project — NICA.jinr.ru.



2. Dubna. Exhibitions. Visit Centrum. JINR Museum

There were done 4 permanent exhibitions in Dubna related to JINR and science popularization.

- JINR Visit Centrum
- Education Center named after Academician A.N. Sissakian
- The Exhibition Center of the Special Economic Zone Dubna
- JINR Museum of Science and Technics



3. Virtual Laboratory of Nuclear Fission

The goal of the project is to include current scientific data into the educational process, to conduct virtual and online laboratory research based on information and communication technologies using modern scientific equipment and data obtained from the existing physical facilities.

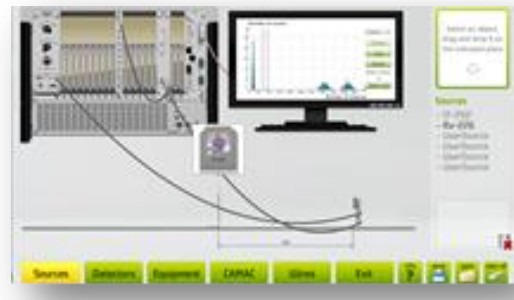
Members, involved in the project:

1. Stellenbosch University, South Africa
2. iThemba LABS, South Africa
3. University of Western Cape, South Africa
4. University of South Africa, South Africa
5. University of Venda, South Africa
6. University of the Witwatersrand, South Africa
7. Joint Institute for Nuclear Research (JINR), Russia
8. National Nuclear Research University MEPhI, Russia
9. InterGraphics LLC, Russia



Results:

1. Software complex “Virtual Laboratory of Nuclear Fission” (theory, lab practicum, quizzes, exercises, ROOT) is developed.
2. Hardware complex “Virtual Laboratory of Nuclear Fission” (real experimental equipment) for student practices at JINR is developed.
3. Interactive Environment for Nuclear Experiment Modeling (setup builder) is developed.
4. Several student practices (students from South Africa, Poland, Czech Republic, Belorussia etc.) are held.
5. The project web-version based on MOODLE (Modular Object-Oriented Dynamic Learning Environment) technologies is developed.



We foresee the following development of the project:

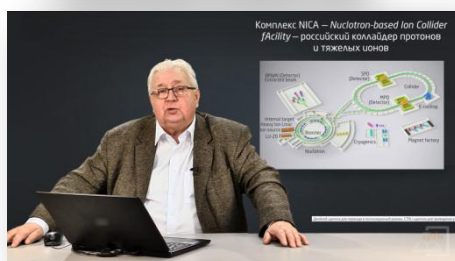
1. Adapt the software to cater for the specifics of the university curricula needs.
2. Adapt the software to cater as a research to specific experimental projects such as AFRODITE and K600 Magnetic Spectrometer.
3. Develop the web-based educational software for easier accessibility of users to the platform.
4. Adjust the specific hardware-software complex “Virtual Laboratory of Nuclear Fission” related to the student training for the work with the LISSA setup at the Stellenbosch University.
5. Prepare the interactive multimedia environment for exhibitions in Russia and South Africa as an advertising tool to potential users.
6. Create opportunities for South African students to spend an extended period for the participation in the development of the project.

7. Organize annual workshops on training researchers and students on the Virtual Laboratory environment and discuss new developments for the project.
8. Expand the user base of the Virtual Laboratory platform.

4. Nuclear physics online courses for MOOCs Coursera and edX intended for university students and developed in collaboration with MEPHI

Since 2014 there is absolutely new approach in education – Massive Open Online Courses (MOOC). At present time about tens millions of students all over the world are using these resource for their education. We think that JINR University Centrum should be involved in modern e-learning process for JINR Member States Universities. There were mastered of these technologies and have been prepared first courses in collaboration with Nuclear Research University MEPHI. For the next 3 years we are planning strong development of this part of project.

coursera



edX



Reports to International Conferences

1. 10 International Conference on the Hands-on Science HSCI'2013, Educating for Science and through Science. Kosice, Slovakia, 2013
2. 11th Science Education with and for Society. International Conference on Hands-on Science. Fábrica Ciência Viva Science Centre, University of Aveiro, Portugal, 2014
3. XIV Conference "Virtual University", Warsaw, 2014
4. 12th International Conference on Hands-on Science HSCI'2014. Brightening our future, 2015
5. XXV Symposium on Nuclear Electronics and Computing - NEC'2015, Montenegro (Budva), 2015
6. The Russian Language Teacher Program in CERN and Dubna, 2013, 2014, 2015, 2016
7. South Africa-Joint Institute for Nuclear Research 10th Collaboration Celebration & Ten-year Review Forum. (CSIR, Pretoria)



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