"INTERACTIVE PLATFORM OF NUCLEAR EXPERIMENT MODELING" AS A MULTIDISCIPLINARY TOOL IN THE TRAINING OF SPECIALISTS IN THE FIELDS OF ICT AND EXPERIMENTAL NUCLEAR PHYSICS

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One of the main trends of the modern university education is the inclusion of experimental data and research methods into the educational process. This report is dedicated to a software and hardware complex used for university students training related to their further work in physical experiments. An important feature of this project is a combination of hands-on and virtual practicum approach. In this approach students work with real physical equipment and software complex to study the electronics and data acquisition system of the LIS experiment [1].

A new approach for conceptualization and skills development in scientific and engineering project work is proposed. In this computer-based approach libraries of various components of nuclear physics experiment (radioactive sources, various types of detectors, instruments and components of nuclear electronics) are used. This is different from traditional labs with defined equipment and measurement methods at the beginning of work.

We plan to integrate this educational tool into the traditional educational process applying the blended learning model. This multidisciplinary tool has possibility to be used by a range of students from different scientific and engineering disciplines e.g. ICT specialists, engineers etc.

Keywords: nuclear experiment modeling, virtual laboratory, instruments and methods for the study of radioactive decays, nuclear fission, data analysis

1. Virtual labs based on real experimental data for development of skills and competences in nuclear physics experimental techniques

One of the main trends of the modern university education is the inclusion of experimental data and research methods into the educational process. It is crucial to ensure that university graduates are able to engage in research in modern scientific laboratories with relative ease.

This project is developing the blended educational model on the basis of the modern physical setup – Light Ion Spectrometer (LIS, see Figure 1). This educational tool has been developed in collaboration with the Flerov Laboratory of Nuclear Reactions. Using this tool students are required to study the nuclear physics phenomenon such as spontaneous fission, which forms the basis for the studies of multi-body decay modes.

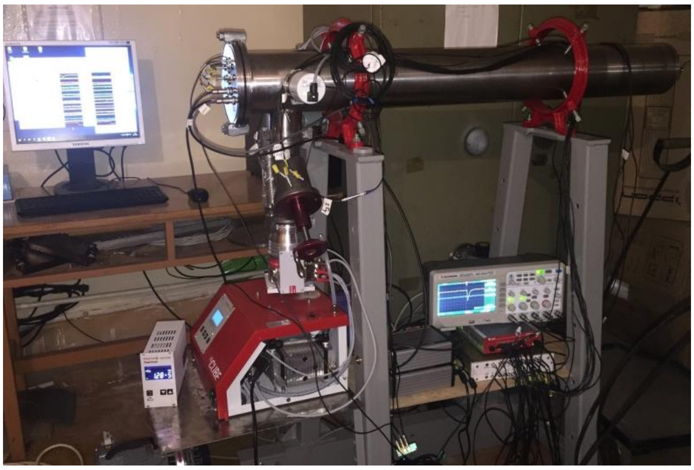

Figure 1. LIS Setup

A distinctive feature of LIS setup is its relative "simplicity", while it uses the state-of-the-art radiation detectors, nuclear electronics and other equipment to make precise measurements. This allows the students in a relatively short training period to go through all the stages of preparation of the experimental setup in order to perform the experiment and obtain physical results.

The physical process of spontaneous fission has been selected, and it was performed modeling and visualization of all the stages of experiment realization, taking of experimental data and their analysis. Education content includes key ideas, interactive quizzes and exercises, a set of interactive laboratory works, interactive practicum devoted to processing and analysis of experimental data using the ROOT platform.

An important feature of this project is a combination of hands-on and virtual practicum approach [2]. In this approach students work with real physical equipment and software complex to study the electronics and data acquisition system of the LIS experiment. This enables students to develop their understanding of principles of operation and typical ways of exploitation of different electronic blocks as training for their independent work with real physical equipment (see Figure 2).

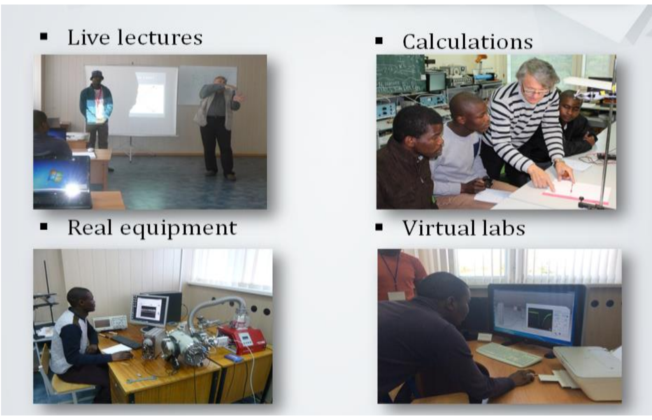

Figure 2. Student Practices

Virtual labs based on real experimental data could help to prepare students for a real experiment, to simplify safety-related issues in real experiments.

Virtual practicum (see Figure 3) includes the following virtual researches [3]:

- Study of signals from pulse generator
- Signal measurement using oscilloscope
- Spectrum registration of scintillation detector with the NaI crystal
- Energy calibration of PIN diode
- Measurement of radiation energies and thickness of ^{252}Cf-sourse
- Calibration from the precision pulse generator
- Time calibrator grading
- Time coincidence counting from cosmic rays
- Time coincidence counting from a pulse generator
- Work with vacuum system for physical experiment
- Assembling of the detector system of the time-of-flight and energy spectrometer
- Work with the CAMAC slave controller. Study of a register module

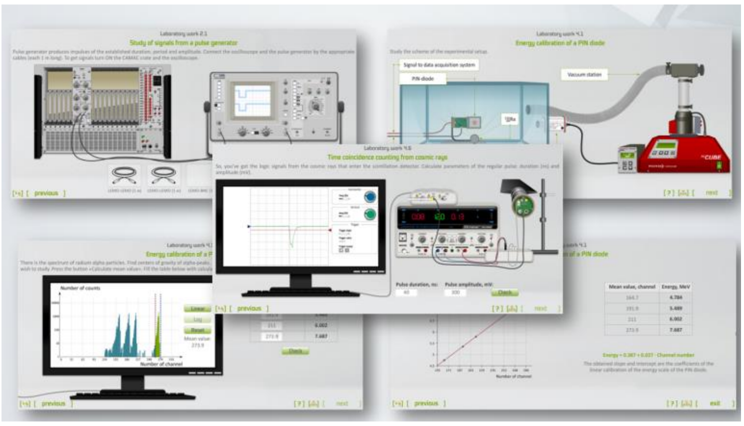
Figure 3. Examples of virtual labs

The following student skills are expected to be gained:

- Spectrometry of alpha particles and heavy charged fragments with the help of modern semiconductor detectors (pin-diodes)
- Time-of-flight measurements using time detectors based on microchannel plates

- Analysis of data from modern digitizers. Measurement of time-of-flight spectra with high precision and the study of plasma delay effects in the registration of fission fragments with high charge in semiconductor detectors
- Processing of the experimental data and obtaining of the mass distribution diagram of the fission fragments

The set of these virtual labs form the competencies that are necessary for students work in a modern experiment in the field of nuclear physics (see Figure 4).

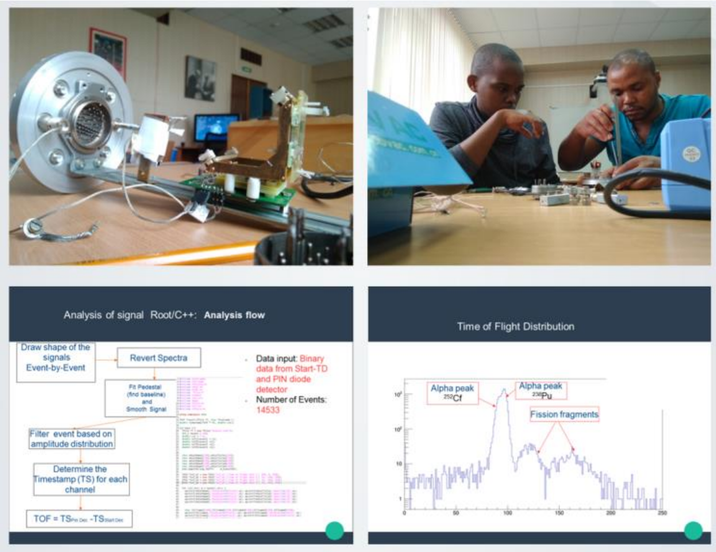

Figure 4. Some results of student practices

2. "Interactive Platform of Nuclear Experiment Modelling" as a multidisciplinary tool in the training of specialists in the fields of ICT and experimental nuclear physics

A new approach for conceptualization and skills development in scientific and engineering project work is proposed. In this computer-based approach libraries of various components of nuclear physics experiment (radioactive sources, various types of detectors, instruments and components of nuclear electronics) are used (see Figure 5). This is different from traditional labs with defined equipment and measurement methods at the beginning of work.

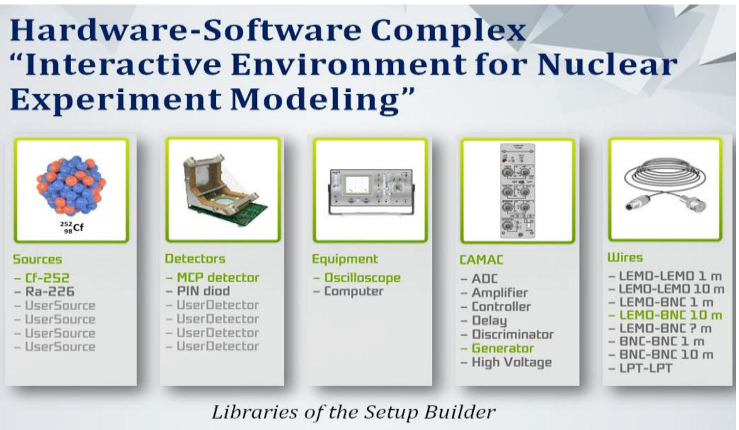

Figure 5. Libraries of the Interactive Environment for Nuclear Experiment Modelling

One of the advantages of this computer-based approach is that students, specializing in the field of experimental nuclear physics, are able to assemble preferred virtual experimental setup using existing components of the libraries. Using high-level programming languages (C ++, C #, etc.) with the set of libraries students can develop new components of virtual experimental setups (see Figure **6**).

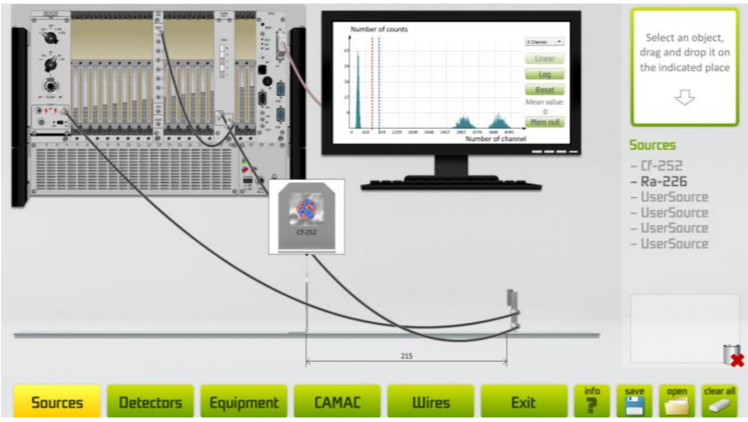

Figure 6. Student can arrange his own setup

This multidisciplinary tool has possibility to be used by a range of students from different scientific and engineering disciplines e.g. ICT specialists, engineers etc.

3. Future plans

Now we are developing Internet version of the project (see Figure 7) based on the Learning Management System MOODLE. This system allows to control the educational process as a tutor, to see the progress of passing the course as a student. Through this environment students can communicate with peers and tutors.

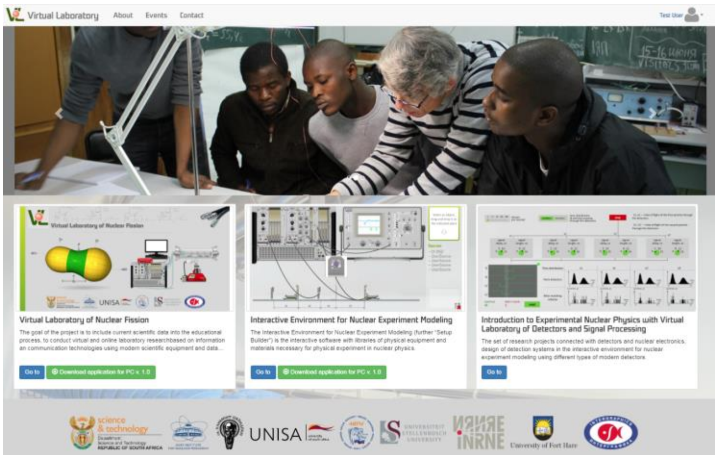

Figure 7. Internet version of the project

The next step of project development is creation of the Interactive educational research laboratory of detectors and signal processing. It is the set of research projects connected with detectors and nuclear electronics, design of detection systems in the interactive environment for nuclear experiment modeling using different types of modern detectors.

4. Conclusion

Students graduated in the fields of nuclear, radiation and particle physics are highly demanded specialists in industry for jobs in nuclear power plants, nuclear regulatory agencies, law-enforcement agencies (nuclear security) etc. Moreover, the basic and the specialized training in nuclear and particle physics allows the best graduates also to pursue academic careers in laboratories from the Large Scale Research Infrastructure.

It has to be noted, that however, that nuclear and particle physics is exclusively an experimental area of research. The experimental techniques used in the field are diverse and involve state-of-the-art electronics and computing. In this respect, the practical training of the students is an essential and extensive part of their education. Nevertheless, this training was hugely underestimated in recent decades and as a result presently is in a stage of constant decline. The aim of the project “Virtual Laboratory” is to develop, design and construct contemporary exercises for students in the field of nuclear and particle physics which consequently to be deployed and used in the respective student laboratories.

In the framework of this project some international student practices on experimental nuclear physics were held. Students studied principles of exploitation of various electronic blocks, worked with different types oscilloscopes (old analogue and modern digital ones), observed and studied signals from different detectors, made some calibrations and analyzed experimental data.

Now the last achievements of the project are being implemented into the educational process at the universities of Russia, JINR Member States and Associate Members.

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