Virtual Laboratory – Virtual Educational Tools and Hands-on Practicum

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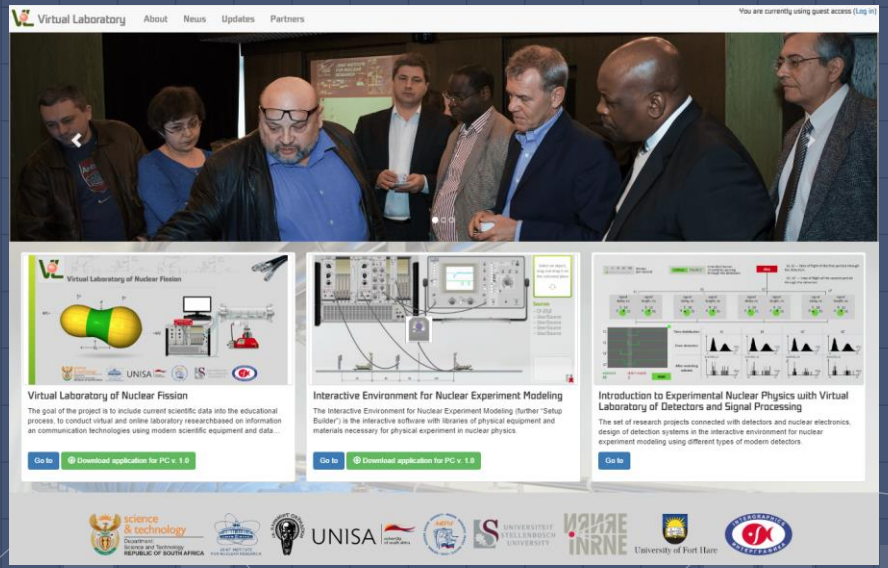
JINR 27th Symposium on Nuclear Electronics and Computing – NEC'2019
Budva, Montenegro
30 September – 4 October, 2019

PROJECT “VIRTUAL LAB”

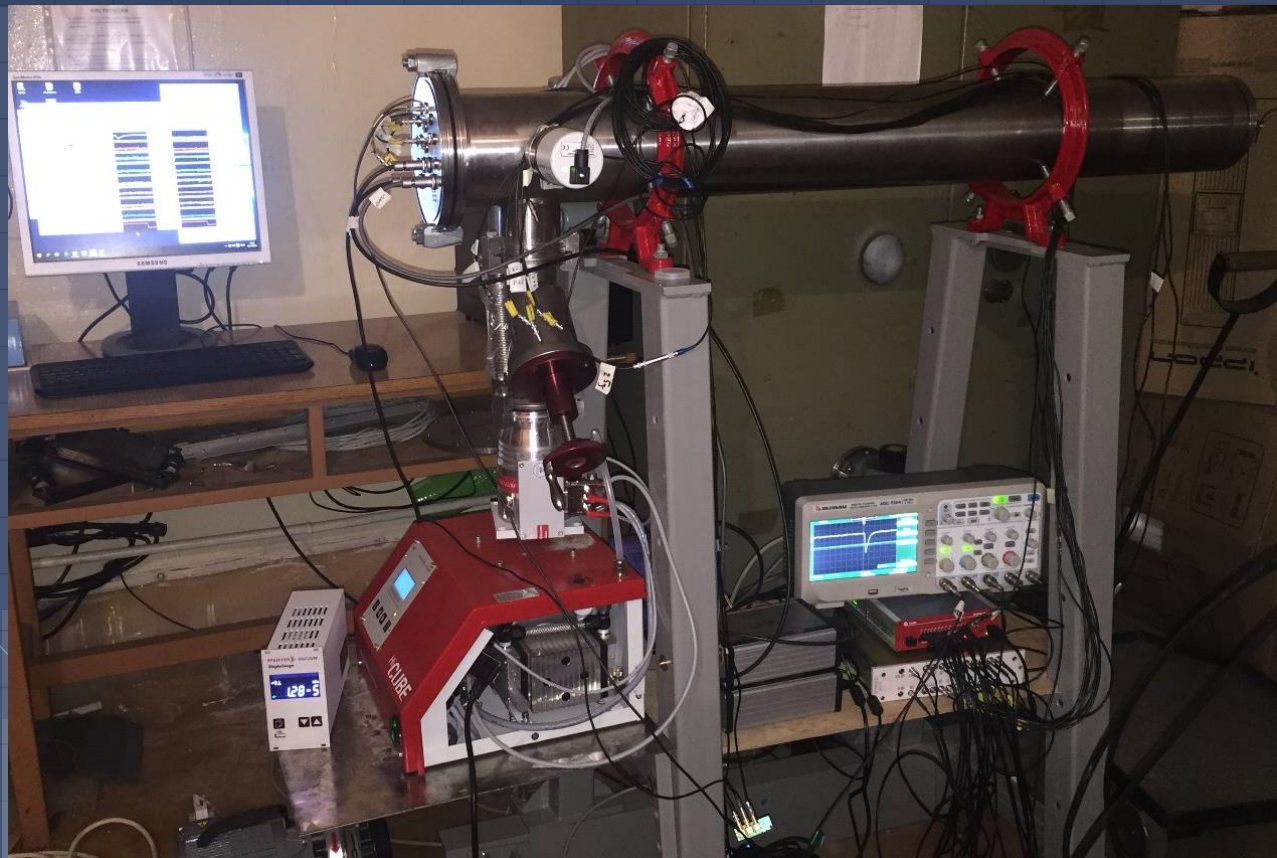
The goal of the project is to include current scientific data into the educational process, to conduct virtual and online laboratory research based on using modern scientific equipment and data obtained from the existing physical facilities.



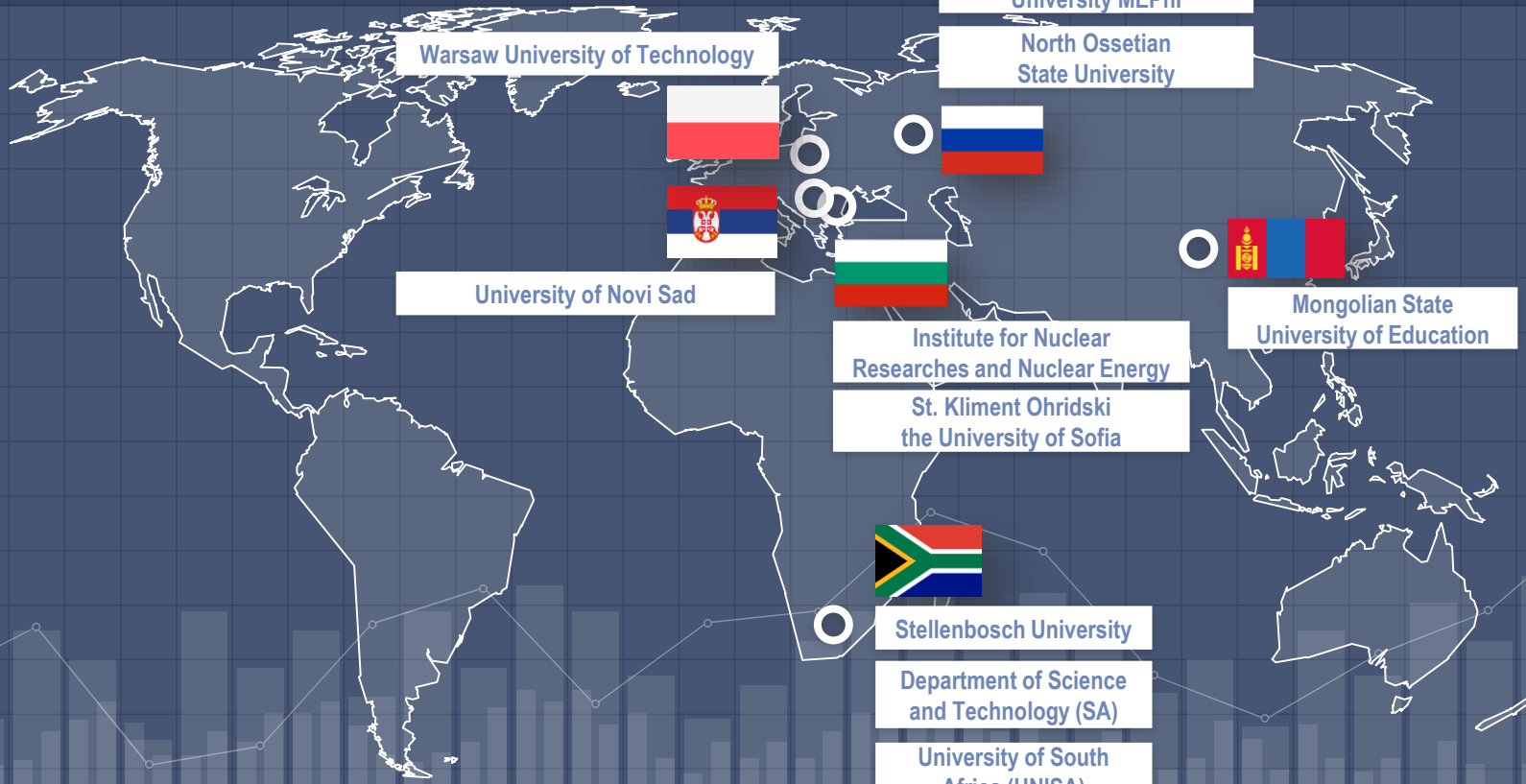
PROJECT “VIRTUAL LAB”. BEGINNING

THE PROBLEM:

How to train students and young specialists to work with modern equipment and real experimental data?



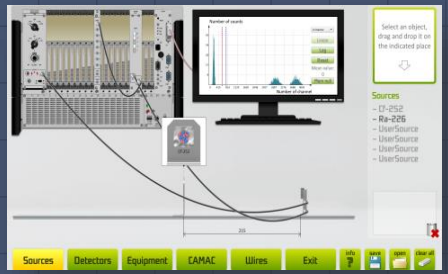
PROJECT “VIRTUAL LAB”



PROJECT “VIRTUAL LAB”

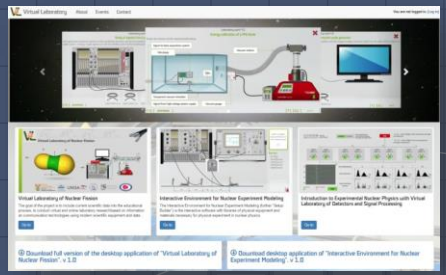
Software complex “Virtual Laboratory of Nuclear Fission”

Interactive environment for nuclear experiment modeling (Setup Builder)



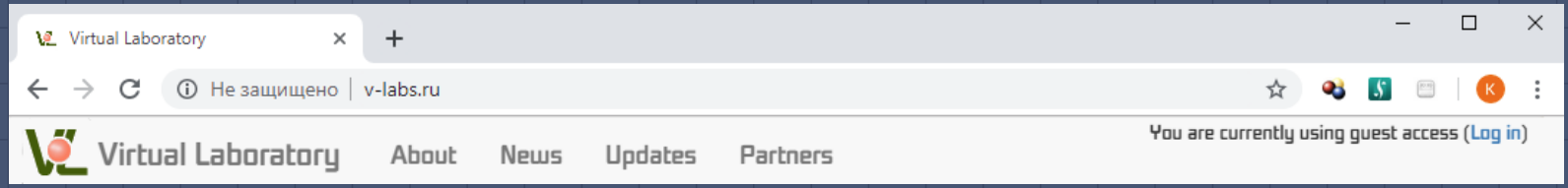
Hardware complex “Virtual Laboratory” for student practices

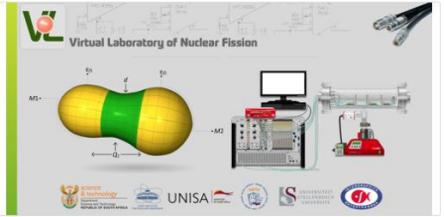
Web-version of the project



WEB-VERSION OF THE PROJECT

http://v-labs.ru/

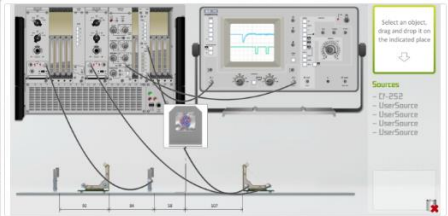




Virtual Laboratory of Nuclear Fission

The goal of the project is to include current scientific data into the educational process, to conduct virtual and online laboratory researchbased on information an communication technologies using modern scientific equipment and data...

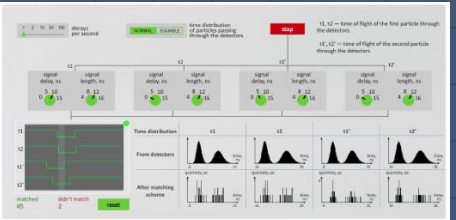
Go to | Download application for PC v. 1.0



Interactive Environment for Nuclear Experiment Modeling

The Interactive Environment for Nuclear Experiment Modeling (further "Setup Builder") is the interactive software with libraries of physical equipment and materials necessary for physical experiment in nuclear physics.

Go to | Download application for PC v. 1.0



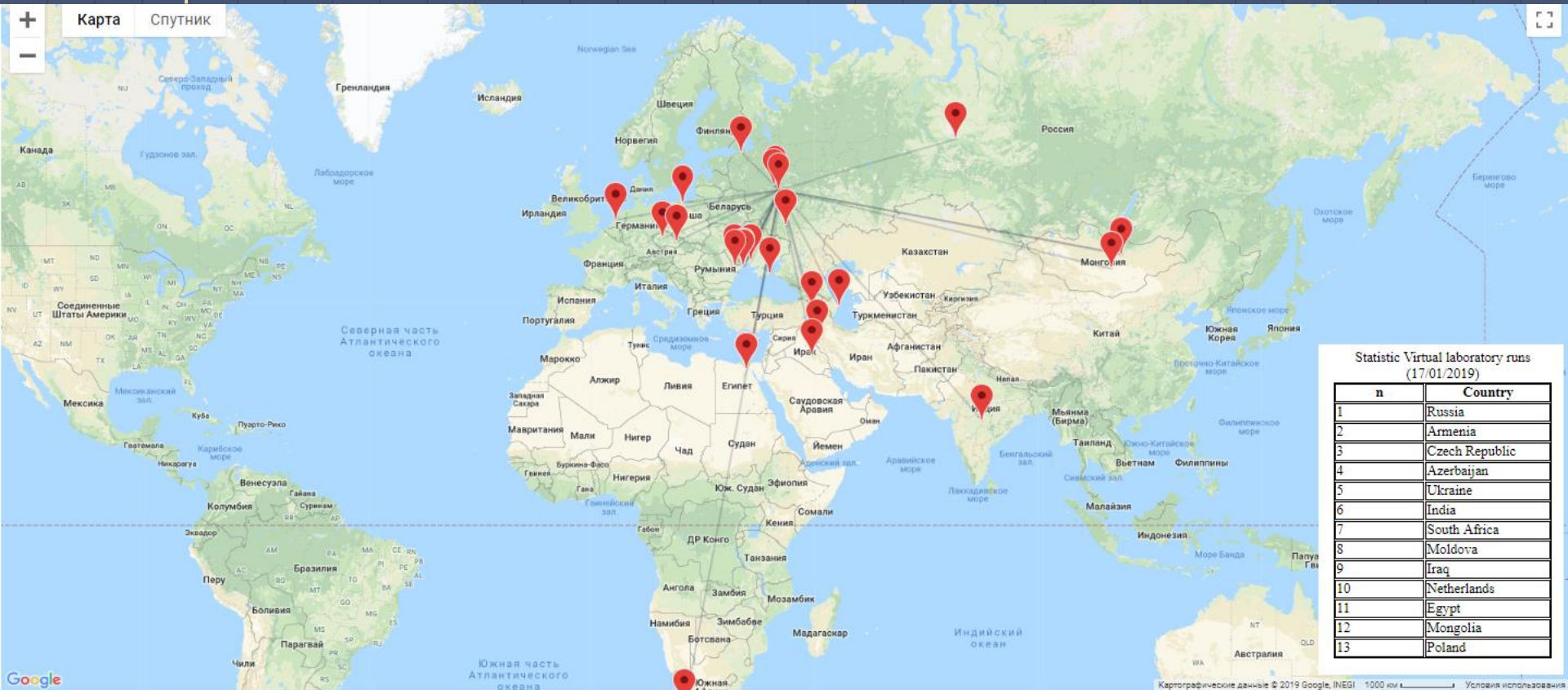
Introduction to Experimental Nuclear Physics with Virtual Laboratory of Detectors and Signal Processing

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.

Go to

WEB-VERSION OF THE PROJECT

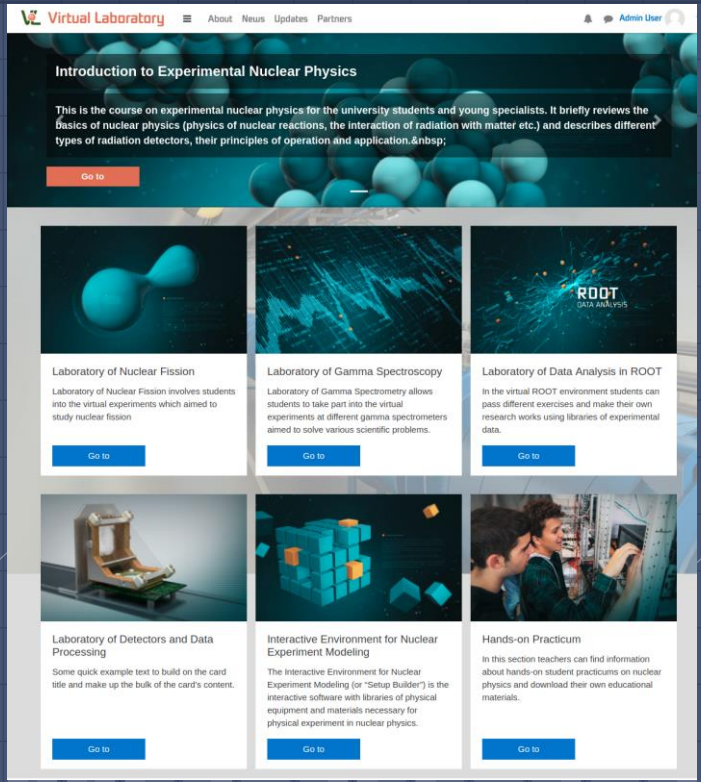
http://v-labs.ru/



CURRENT STATUS

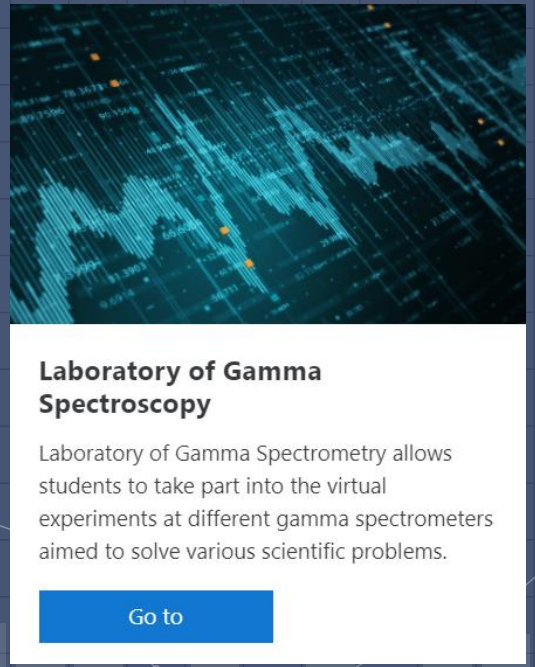
New structure:

- Introduction to Experimental Nuclear Physics
- Laboratory of Nuclear Fission
- Laboratory of Gamma Spectrometry
- Laboratory of Data Analysis in ROOT
- Laboratory of Detectors and Data Processing
- Interactive Environment for Nuclear Experiment Modeling
- Hands-on Practicum



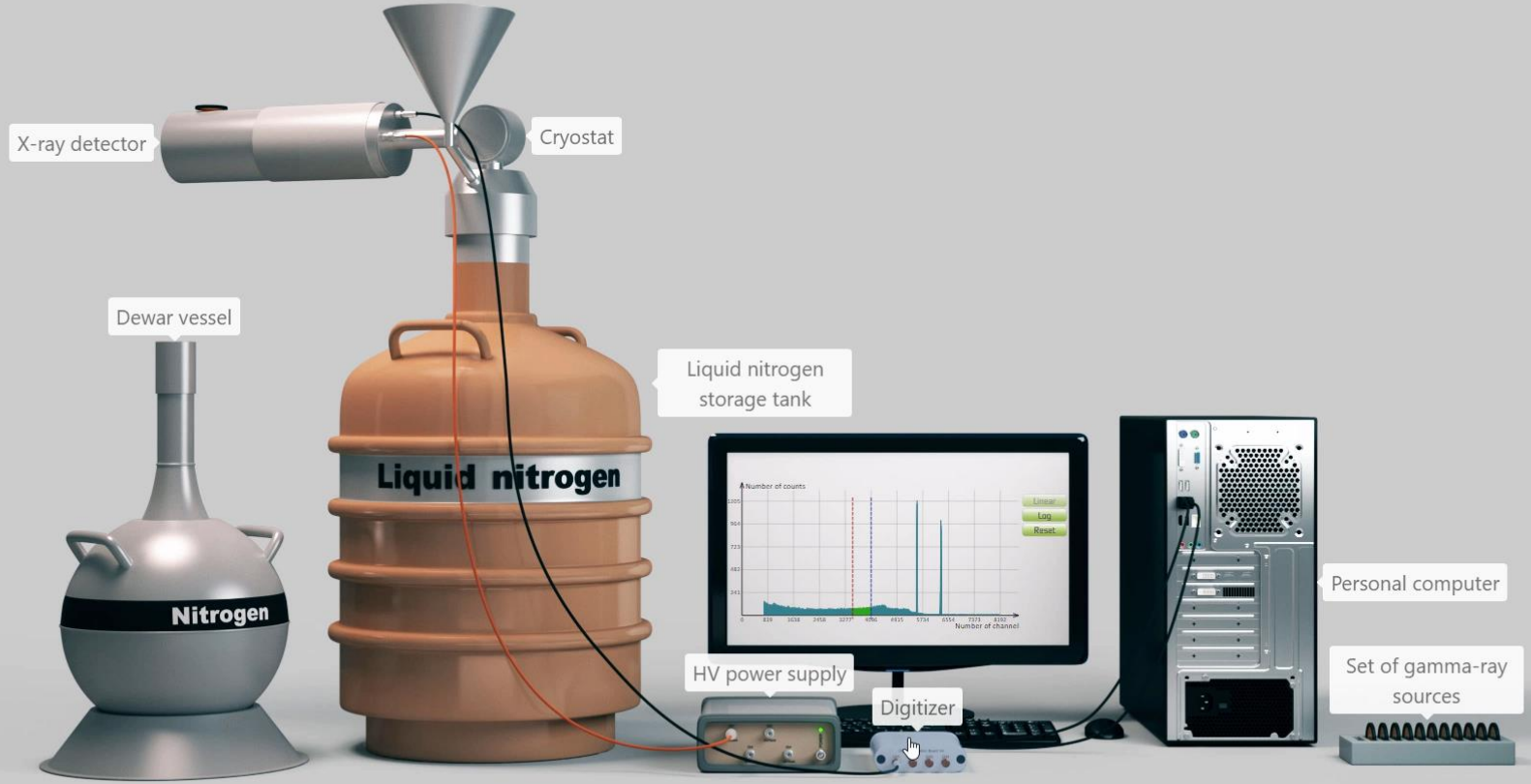
VIRTUAL LABORATORY OF GAMMA SPECTROMETRY

- Scintillation gamma spectrometer
- Semiconductor Ge(Li) gamma spectrometer
- X-ray measurements. Moseley's law
- Attenuation of gamma radiation (remote experiment)
- ROOT for gamma spectroscopy
- Practical task from low background laboratory

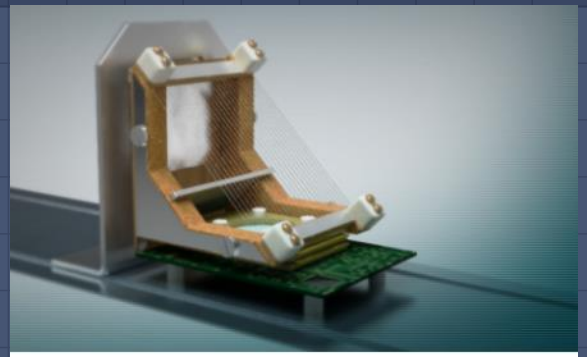


Lab 1. X-ray Spectrometer structure

Study the scheme of the experimental setup. Click on the elements to see more information.



NEAREST FUTURE



Laboratory of Detectors and Data Processing

Some quick example text to build on the card title and make up the bulk of the card's content.

Go to

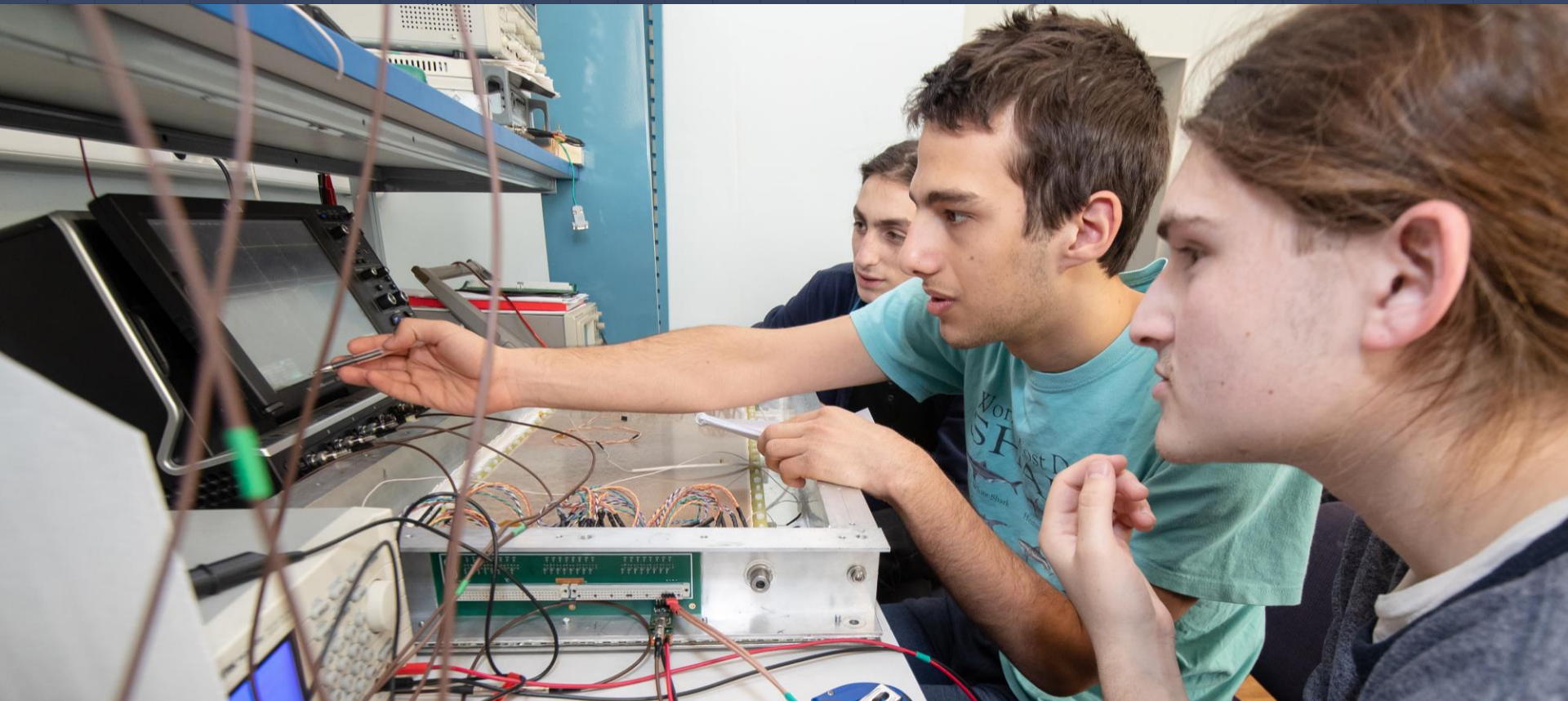
Laboratory of Data Analysis in ROOT

In the virtual ROOT environment students can pass different exercises and make their own research works using libraries of experimental data.

Go to

LABORATORY OF DETECTORS AND DATA PROCESSING

LABORATORY OF DETECTORS AND DATA PROCESSING



```
#include "TCanvas.h"
#include "TMath.h"
#include "TH1.h"
#include "TF1.h"
#include "TRandom.h"
#include "TSpectrum.h"
#include "TVirtualFitter.h"
Double_t fitGaus(Double_t *x, Double_t *par)
{
   Double_t arg = 0;
   if (par[2] != 0) arg = (x[0] - par[1])/par[2];
   Double_t fitval = par[0]*TMath::Exp(-0.5*arg*arg);
   return fitval;
}
void spectraGauss_Co60_1_20may2019_fitCh(Int_t np=10)
{
    TH1F *h = new TH1F("h", "Spectrum channel number for Co^{60}", 4096, 0, 4095);

    ifstream in;
            in.open("Co60_1.txt", ios::out);

    const Int_t n=20000;
    Int_t channel_1[n], event_1[n];
    Int_t i=0, ncut=4096;
    Double_t par[11];

    for (i=0; i<=ncut; i++)
    {
        in>>channel_1[i]>>event_1[i];
            if (i<=10) cout<<"ch="<<channel_1[i]<<" evCount="<<event_1[i]<<endl;
            h->Fill(channel_1[i], event_1[i]);
    }
    TCanvas *c1 = new TCanvas("c1", "c1", 10, 10, 1000, 900);
             c1->cd();
              h->Draw();
}
```

The subroutine for Gaussian function

Figure 2. Code for a spectrum is plotted by the histogram in the Root system.

Step 2: Run the macro in the Root system by the following commands.

```
root [0] .cd e:/GoogleDrive/useIoVM1/CosmicRay4
root [1] .x spectraGauss_Co60_1_20may2019_fitCh.c
```

Figure 3. Commands for compile a code in the Root system

Step 3: Select the part of the spectrum along horizontal axis press the left mouse button on the initial position of the peak (about 380), drag it along the axis and release at the end position of the peak (about 430). The spectrum should look like Figure 5.

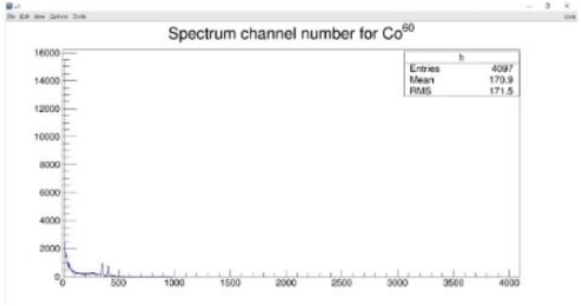


Figure 4. Spectrum for Co^{60}

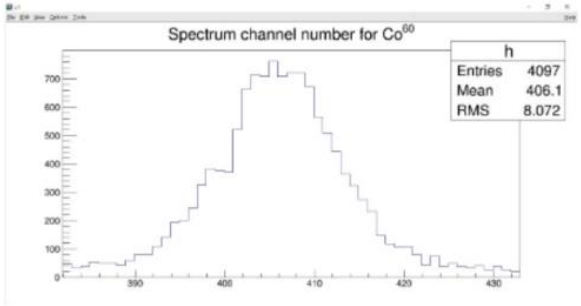


Figure 5. The selection part of spectrum

Step 4. Fit the peak. Right click on the peak and choose fit panel on the dropdown menu. The new fit panel window opens like below image.

МОНГОЛ УЛСЫН
БОЛОВСРОЛЫН ИХ СУРГУУЛЬ

HANDS-ON PRACTICUM

STUDENT PRACTICIES

STUDENT PRACTICIES

- Lectures of JINR professors and leading specialists

- Lab exercises

- Virtual labs as training before working with real equipment

- Work with real experimental setups

PRACTICUM FOR BEGINNERS

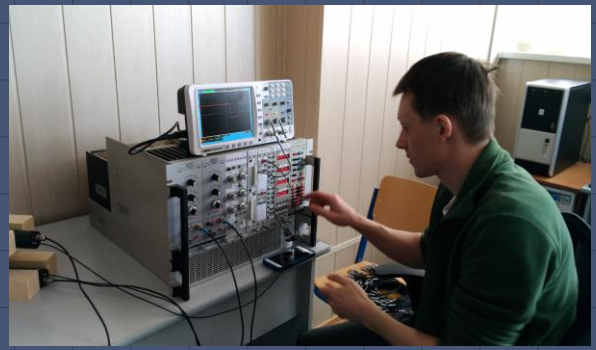
Basics of electrical pulse measurements:

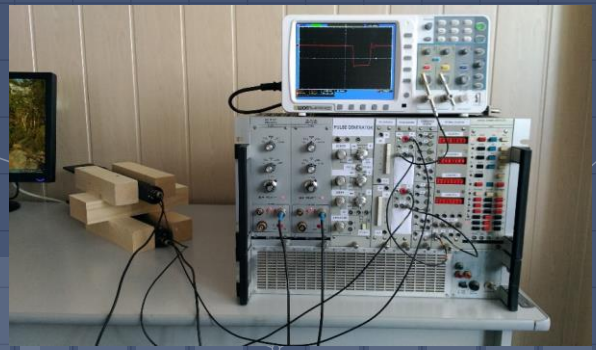
- work with a digital oscilloscope and a pulse generator,
- study of signals from a pulse generator;
- study of the signal delay in cables,
- study of CAMAC crate,
- work with CAMAC blocks: delay module, counter, signal splitter,
- study of coincidence counting.

PRACTICUM FOR BEGINNERS

Study of cosmic rays:

- work of scintillation counters,
- work with high voltage (HV) power supply,
- principles of work of coincidence scheme,
- calculation of the number of coincidences for two scintillation counters for a time period,
- calculation of the number of cosmic particles that enter 1 dm2 of scintillation counter per 1 minute,
- observation of signals from cosmic radiation.

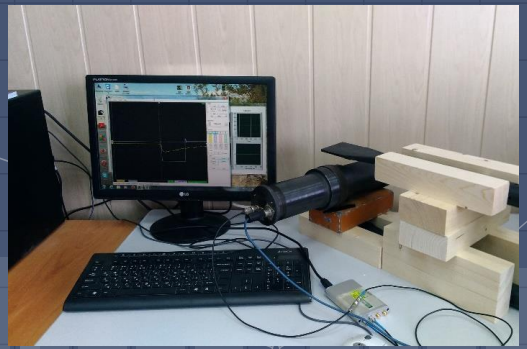




PRACTICUM FOR BEGINNERS

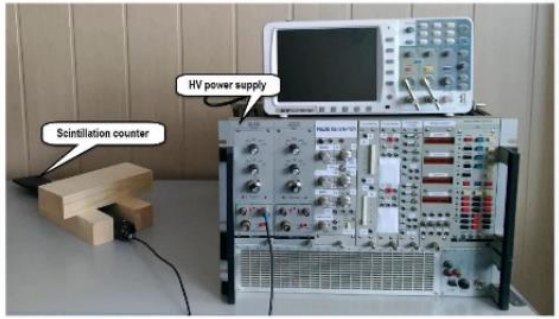
Telescope for studies of cosmic rays:

- to study 4-channel digitizer DRS4 with corresponding software,
- to study scintillation detector based on NaI crystal,
- to assemble a cosmic ray telescope,
- to study principles of work of the cosmic ray telescope
- to study spectrum from the cosmic ray telescope.



Lab instructions:

1) Feed high voltage to the scintillation counter No. 1.*



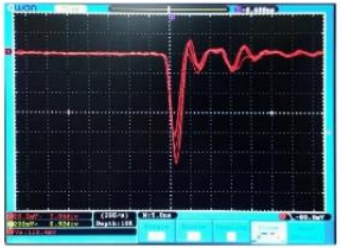
For this, using a cable, connect the output of HV power supply with HV input of the scintillation counter.

Attention! Work safely with high voltage power supply! Before work with the block of HV power supply, make sure that it is turned off and all the controls are zeroed. Then turn on CAMAC crate and turn on the block of HV power supply. Make sure that the activation indicator light went on.

* The devices with power supply at the **Station No. 1** and the **Station No. 2** can differ from described in this document. See **Annex 1** ("Power supplying of scintillation counters at stations No. 1 and No. 3") to this document.

2) Connect the scintillation counter with the oscilloscope.

3) Gradually increase the voltage until you will see stable signals on the oscilloscope screen.

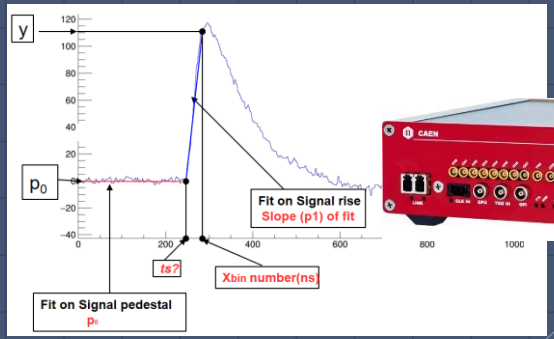


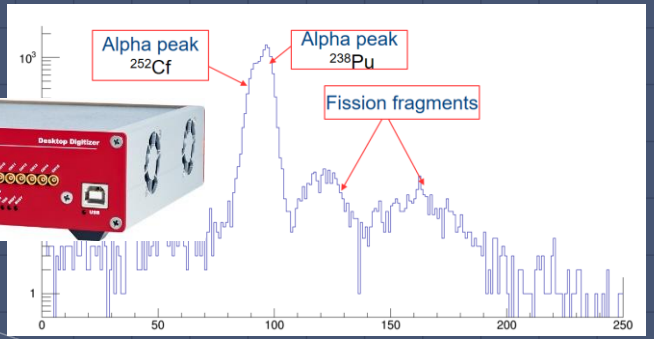
Ilay Samuel Kimel
Tal Cohen

STUDENT RESULTS

Kehinde Tomiwa

Data analysis of LIS spectrometer signals from 5 GS/s Switched Capacitor Digitizer





UNIVERSITY STUDENT PRACTICIES

- 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)

HIGH SCHOOL STUDENT PRACTICIES

- Practice for high-school students from Israel 2018
- Practice for high-school students from Israel 2019
- Practice for high-school students from Czech Republic 2019
- Practice for high-school students from Germany 2019

STUDENT PRACTICIES. FEEDBACK

Joint Institute for Nuclear Research

SCIENCE BRINGING NATIONS TOGETHER

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News | World science | Organization | EDUCATION | Grants | Patents | Publications | Culture | Agenda

3-day visit of school students from Israel

Education, 21 March 2019

Elena Simon, Physics teacher at HEMDA: *"We had an opportunity to touch real experimental work here; it was the thing that we liked most about JINR. The experience of the last year showed that students were satisfied with lectures and excursions, but most of all they were impressed by hands-on activities. So this year we decided to concentrate on the practical part. This is the reason why we came back to JINR, and more likely we will come again in the future. We were able to show our students what modern experimental research is like. I would like to note that our group has been paid a lot of attention, we are very pleased and truly appreciate it. In our turn, we are trying to make our visit useful for the institute, that is why we prepare and "tune" our students accordingly. It gives a possibility of testing the techniques that you develop, and, for our part, we are ready to give a feedback. The guys very appreciate the personality of G.N. Flerov. They took many photos next to his portrait because the great-niece of this outstanding scientist works in our Center. This cultural and historical connection of Dubna and Tel Aviv lives on, and our students always remember about it."*

Farber Arzi Orr, student: *"We came here to see "Big Physics" and high technologies by our own. We had studied in theory the largest part of what we saw here, and it was great to be able to touch it. Staying in Russia is unforgettable not only because of the weather but also because of the culture. We could feel what it is like to be a part of JINR. We listened to lectures in English and joined the international team for several days thus feeling that we were a part of it. We enjoyed hands-on work very much: it turned out to be the most valuable part of the visit for me."*

OFF-SITE WORKSHOPS

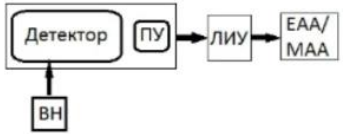
USE IN EDUCATION

Калибриране на спектрометър

Това упражнение е създадено благодарение на Програма за сътрудничество ОИЯИ – България

Цел на упражнението: Целта на това упражнение е да се осмисли процедурата по калибриране на спектър, получен от източник на йонизиращо лъчение.

Детекторите на йонизиращи лъчения са едни от основните инструменти на експерименталната ядрена физика и нейните приложения. Предназначението им е не само да регистрират наличието на радиация, но и да дават информация за енергията на частиците, тяхната траектория, скоростта и т.н. Отдадената и работния обем на детектора енергия на лъчението се превръща в достъпен за човека сигнал: регистриране на електричен импулс, светлина, фотографско изображение, звук. От вида на детектора зависи в какво ще се трансформира отдадената енергия. Тенденцията в съвременния ядрено-физичен експеримент е да се използват преди всичко детектори с електричен сигнал, тъй като те най-лесно позволяват включването на достиженията на съвременната електроника и компютри в следващия етап на обработка на информацията. В това упражнение няма да се спираме на изясняване действието на всеки от основните детектори, а ще разгледаме най-общо принципа на един γ-спектрометър. На Фиг. 1. е показана неговата блок-схема.



Фиг. 1. Блок-схема на γ-спектрометър

Основните елементи са детектор за регистриране на йонизиращо лъчение, на който се подава високо напрежение (ВН). Импулсите от детектора се подават на входа на предусилвателя (ПУ), чиято роля е да предотврати затихването на сигнала по коаксиалните кабели до следващото стъпало – линейния импулсен усилвател (ЛИУ). На Фиг. 2 може да се види как изглеждат импулсите на изхода на усилвателя. Те са положителни с отрицателна "опашка". Последната се появява от свойствата на импулсния усилвател, който, освен че усилва импулсите, ги формира така, че амплитудите им да бъдат по-точно определени от дискриминатора (амплитудния анализатор).

СОФИЙСКИ УНИВЕРСИТЕТ
„СВ. КЛИМЕНТ ОХРИДСКИ“
основан 1888 г.

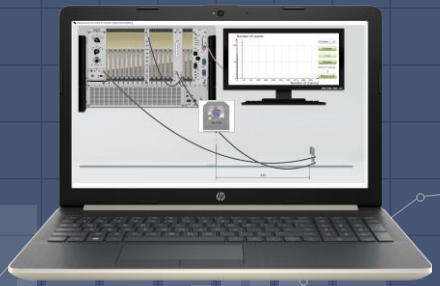
BACHELOR THESES OF DUBNA UNIVERSITY STUDENTS

"Development of elements of the Interactive Environment of Nuclear Experiment Modeling"

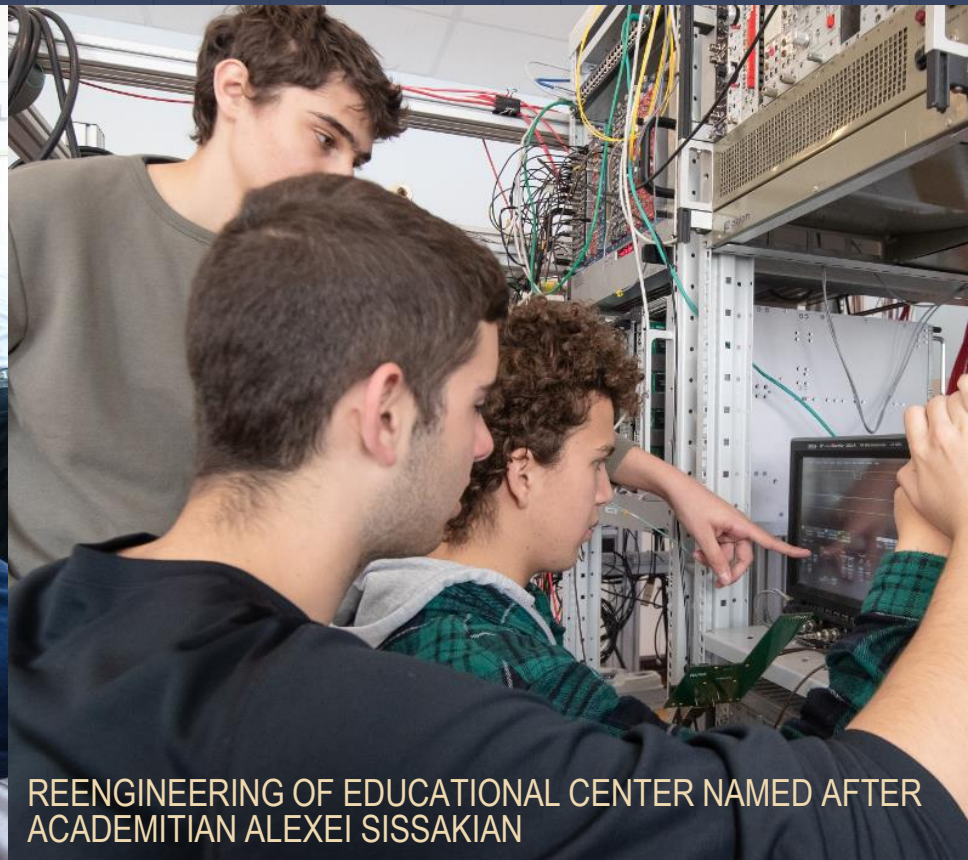
Smagin Vasily

"Development of the virtual radiation source for the Interactive Environment of Nuclear Experiment Modeling"

Korolev Alexander



FUTURE PLANS WITH DUBNA UNIVERSITY



REENGINEERING OF EDUCATIONAL CENTER NAMED AFTER ACADEMITIAN ALEXEI SISSAKIAN

THANKS!

We invite teachers, students and researchers from all over the world to join to our VLab Project as users or developers!