



Introducere în Laboratorul Virtual



Institutul de Chimie, Chișinău, Republica Moldova

Institutul Unificat (Internațional) de Cercetări Nucleare (IUCN),

Laboratorul de fizică a neutronului, Dubna, Russia

inginer, Constantin Hramco

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Planul prezentării:

1. *Institutul unificat de cercetări nucleare (IUCN), informație generală;*
2. *Introducerea în laboratorul virtual IUCN;*
3. *Activitatea personală în IUCN.*



Institul Unificat (Internățional) de Cercetări Nucleare

Organizație internațională, interguvernamentală. Centru de cercetări științifice, exemplu perfect al integrării cercetărilor teoretice, fundamentale și experimentale, dezvoltarea și aplicarea tehnologiei de vârf și a învățământului universitar:

- 7 laboratoare;
- Mai mult de 5000 de angajați;
- Dintre ei peste 1200 cercetători științifici;
- Printre ei academicieni sau membri corespondenți ai academilor de științe naționale;
- Peste 260 doctori habilitați;
- 560 doctori;
- Și peste 2000 ingineri și tehnicieni [1].

1. <http://www.jinr.ru/about-en/>



Institutul Unificat (Internățional) de Cercetări Nucleare

Member States

	Armenia		Azerbaijan		Belarus
	Bulgaria		Cuba		Czech Republic
	North Korea		Georgia		Kazakhstan
	Moldova		Mongolia		Poland
	Romania		Russia		Slovakia
	Ukraine		Uzbekistan		Vietnam

Associate members

	Egypt		Germany		Hungary
	Italy		South Africa		Serbia

- *18 țări membri;*
- *6 țări membri asociați;*
- *Acorduri de colaborare cu 62 de țări [2].*

Institutul Unificat (Internățional) de Cercetări Nucleare

Laboratorul de fizică a neutronului

■ Home ■ FLNP ■ History ■ Facilities ■ Structure ■ User Club ■ Education ■ Local network

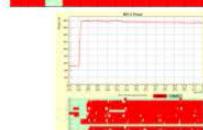


Frank Laboratory of Neutron Physics is one of the laboratories of the Joint Institute for Nuclear Research (Dubna, Russia) that investigates the neutron as an elementary particle using various instruments, and employs the neutron as an instrument to investigate the structure and dynamics of condensed matter, including crystals and nanosystems, functional materials, complex liquids and polymers, rocks, etc. so that our findings could find application in molecular biology and pharmacology, engineering diagnostics and in other fields of science and technology.

IBR-2 Status ON

Current cycle: February 06, 20:00 –
February, 16 18:00

Beam No / Current State:



Current status
Work schedule
Change in the operation of the
reactor in 1 and 2 cycles

Events

FLNP SEMINAR, January 25, 2018
(Thursday), 15:00, FLNP Conference
hall (3rd floor)

IVANOV A.S.

Peter the Great St. Petersburg
Polytechnic University, St. Petersburg,
Russia
Institute Laue-Langevin, Grenoble,
France

Spectra of magnetic and lattice
excitations in high-temperature
superconductors

[Read more ...](#)

News

Program for measuring neutron spectra of the moderator on beamlines 7,
8, and 10.
Program

Reactor power starting from the 2nd cycle

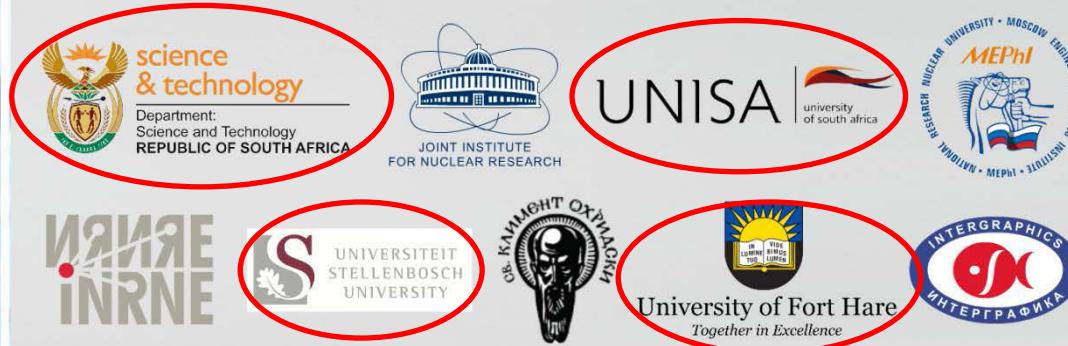
Dear colleagues,
Please note that for technical reasons, starting from the 2nd
cycle (06.02.2018) the reactor will operate at an approximate power of
1820-1830 MW.

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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.



1. Welcome Words
2. About the Project
3. Manual
4. Developers

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Cristian Netling Barnard(afric. Christiaan Neethling Barnard) — cardiochirurg african, pentru prima dată, la 03.12.1967, a efectuat transplantarea cu succes a inimii omenești [4].

Introducere în laboratorul virtual

Virtual Laboratory of Nuclear Fission

About the Project

The purpose of this electronic educational course is to help students, who study experimental nuclear physics, to prepare to their first research activities in the modern scientific laboratories. The subject of the course is the study of radioactive decay processes and spontaneous fission in particular.

Research work in the field of experimental nuclear physics is connected with the solution of various investigating and inventive tasks which require knowledge of nuclear physics and experimental equipment. This project, based on the example of the real experimental setup, familiarizes students with techniques of nuclear physics and confronts them with tasks that require the ability to apply this knowledge in practice, simulating the operation of the experiment.

The subject of the theory of spontaneous fission was chosen not by chance. This process is most important among all the processes of nuclear decay, because exactly it limits the nuclear mass, defines the bounds of the periodic system of chemical elements and consequently the appearance of the Universe. At the same time, experiments, which introduce students to this process, do not require expensive acceleration time and are quite compact.

The LIS (Light Ions Spectrometer) setup developed at the Flerov Laboratory of Nuclear Reactions in Dubna was chosen as an example of a real experiment. The LIS setup is the double arm time-of-flight energy spectrometer of fission fragments. Using this setup students are introduced to the procedure of particle registration and measuring of their characteristics, semiconductor detectors and time stamp detectors, data acquisition systems and data processing algorithms.



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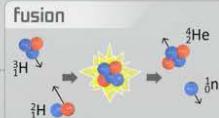
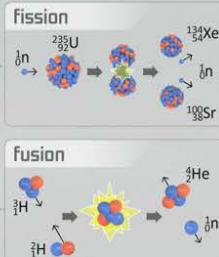
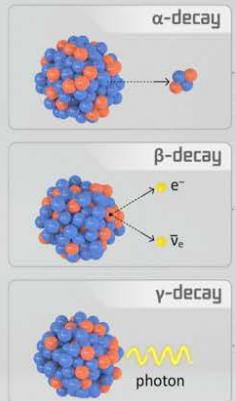
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Virtual Laboratory of Nuclear Fission



Section title •

Some Concepts of Nuclear Physics



Subsections (active elements)



1. Introduction
2. Proton-Neutron Nuclear Model
3. Mass – Energy – Momentum
4. Nuclear Energy: Fusion and Fission
5. Radioactivity:
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Developers



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Reference Book



Basic formulas

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z



Einstein's mass-energy relation

Einstein correctly described the equivalence of mass and energy as "the most important upshot of the special theory of relativity" (Einstein, 1919), for this result lies at the core of modern physics.

$$E_0 = mc^2,$$

where:

E_0 – energy of the physical system,

m – total mass of the system,

c – speed of light (~300,000 km/s or 186,000 miles/s).

Electrical charge distribution in the nucleus



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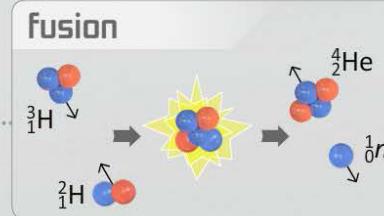
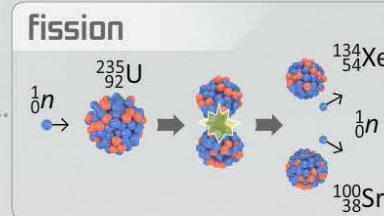
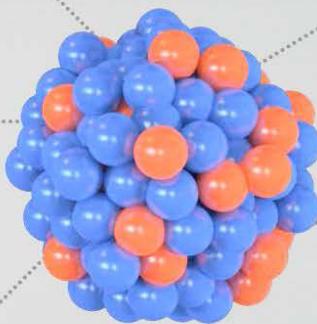
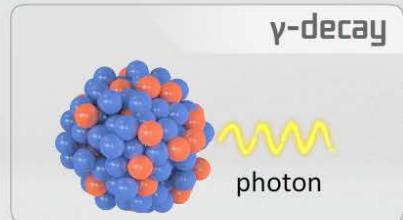
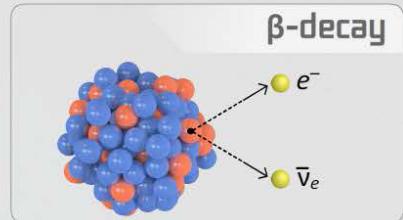
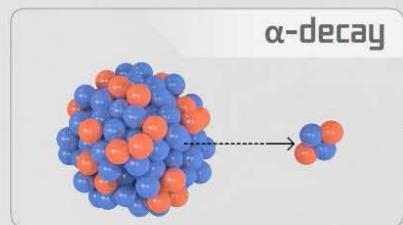
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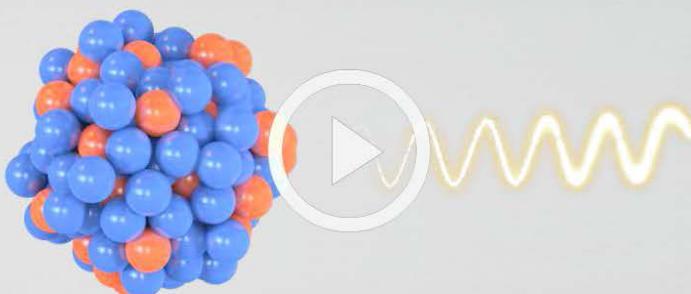
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Gamma Decay

After a decay reaction, the nucleus is often in an "excited" state. This means that the decay has resulted in producing a nucleus which still has excess energy to get rid of. Rather than emitting another beta or alpha particle, this energy is lost by emitting a pulse of electromagnetic radiation called a gamma ray. The gamma ray is identical in nature to light or microwaves, but of very high energy.



Gamma decay

Just like electrons of atoms, the nuclei of atoms can also transition between energy states. When the nucleus of an atom moves from an excited state to a ground state, it releases electromagnetic radiation



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1/20. Who discovered the three different types of radiation?



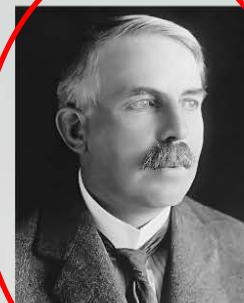
James Chadwick



Niels Bohr



Werner Heisenberg



Ernest Rutherford



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1/20. Who discovered the three different types of radiation?



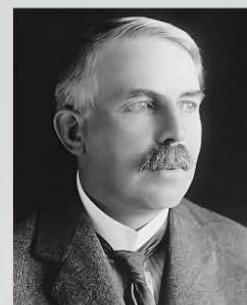
James Chadwick



Niels Bohr



Werner Heisenberg



Ernest Rutherford

WRONG!

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Virtual Laboratory

1. The radon-220 isotope undergoes alpha decay. Write down the equation of this process.

Type here •



50 Sn tin	51 Sb antimony	52 Te tellurium	53 I iodine	54 Xe xenon
82 Pb lead	83 Bi bismuth	84 Po polonium	85 At astatine	86 Rn radon
${}^0_1 e^-$	${}^0_1 e^+$	${}^0_0 \bar{\nu}_e$	${}^0_0 \bar{\nu}_e$	γ

• Drag & drop

WELL DONE!

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Some Concepts of Nuclear Physics

1. The radon-220 isotope undergoes alpha decay. Write down the equation of this process.

Type here •

$$\begin{array}{c} 220 \\ 86 \end{array} \text{Rn}_{\text{radon}} \rightarrow \begin{array}{c} 216 \\ 84 \end{array} \text{Bi}_{\text{bismuth}} + \gamma$$

Drag & drop

50 Sn tin	51 Sb antimony	52 Te tellurium	53 I iodine	54 Xe xenon
82 Pb lead	83 Bi bismuth	84 Po polonium	85 At astatine	86 Rn radon
${}_{-1}^0 e^-$	${}_{1}^0 e^+$	${}_{0}^0 \bar{\nu}_e$	${}_{0}^0 \bar{\nu}_e$	γ
${}_{-1}^0 e^-$	${}_{1}^0 e^+$	${}_{0}^0 \bar{\nu}_e$	${}_{0}^0 \bar{\nu}_e$	${}_{2}^4 He$

$$\begin{array}{c} 220 \\ 86 \end{array} \text{Rn} \rightarrow \begin{array}{c} 216 \\ 84 \end{array} \text{Po} + \begin{array}{c} 4 \\ 2 \end{array} \text{He}$$

WRONG !



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How to Measure Radioactivity



Periodisches System der Elemente.							
Gruppe 0.	Gruppe I.	Gruppe II.	Gruppe III.	Gruppe IV.	Gruppe V.	Gruppe VI.	Gruppe VII.
1.	H 1						
2.	He 4	Li 7	Be 9	B 11	C 12	N 14	O 16
3.	20Ne	23Na	24Mg	27Al	28Si	31P	32S
4.	40Ar	K 39	Ca 40	Sc 45	Ti 48	D 51	Cr 52
5.		64Cu	65Zn	70Ga	72Ge	75As	79Se
6.	Kr 82	Rb 85	Sr 87	U 89	39Kr	90Ru	100Rh
7.		108Ag	112Cd	114In	119Sn	122Sb	128Te
8.	X 131	Cs 133	Ba 137	La 139	Fr 178	Ta 182	W 184
	Em 222	Ra 226	Rc 230	Th 232	Pa 235	U 238	



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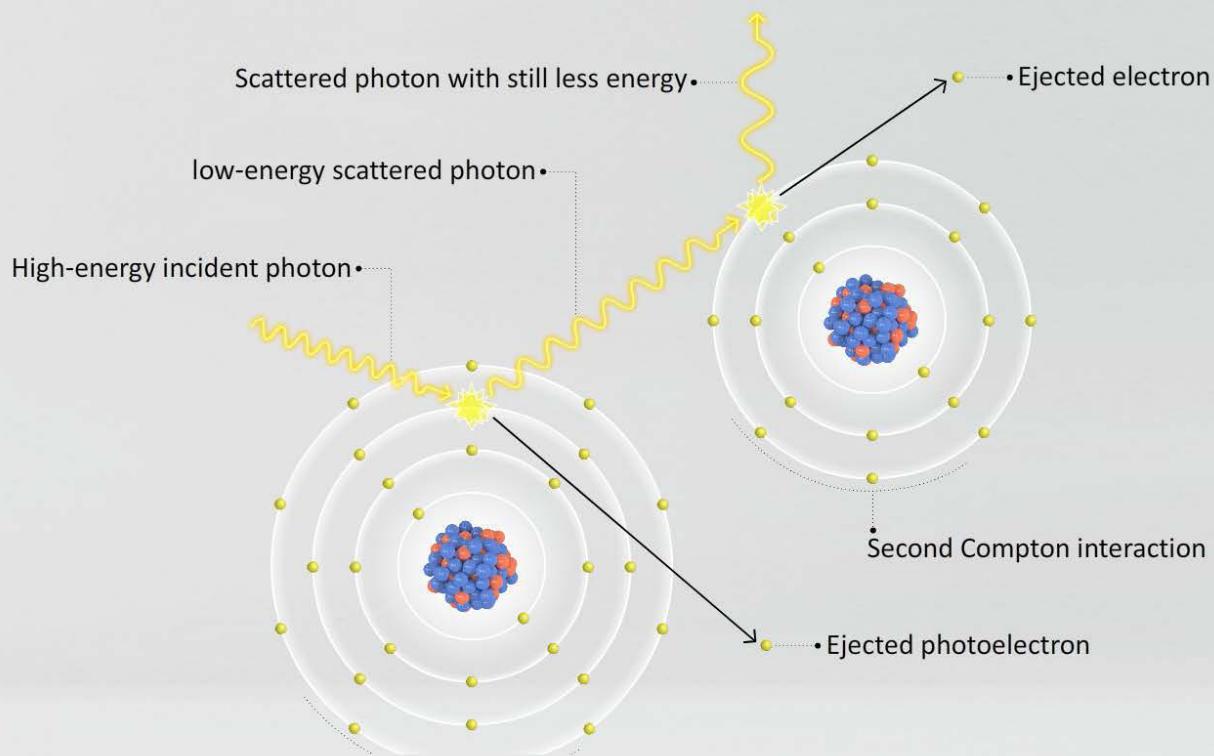
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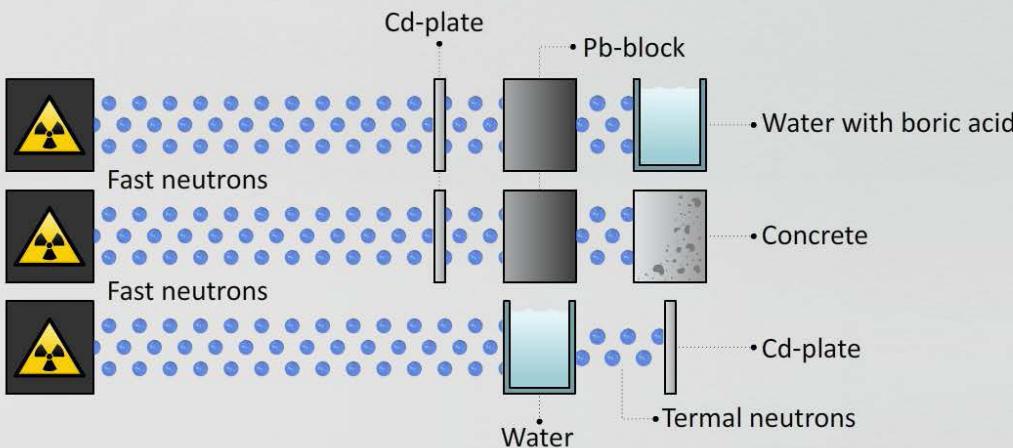


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How to Measure Radioactivity

neutrons can be obtained with materials containing hydrogen or other light nuclei (like water, wax, or concrete).



Shielding of Neutrons

The interaction of neutrons with boron nuclei is the main mechanism used for neutron detection:



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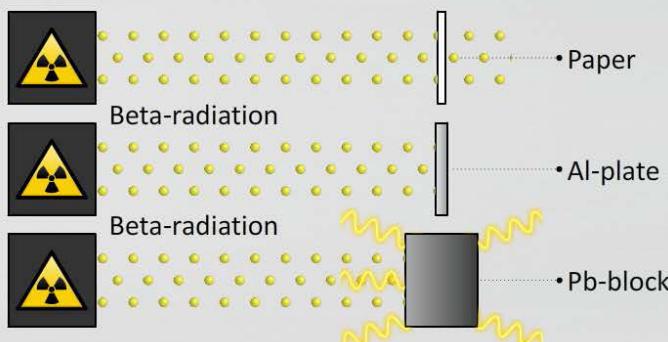
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How to Measure Radioactivity

M-Shell L-Shell K-Shell

Mechanism of bremsstrahlung

Like alpha particles, betas have a characteristic average traveling distance (range) through matter that is dependent upon their initial kinetic energy. Beta particle range may be expressed as distance traveled in a certain medium. For example, beta particle with energy about 2 MeV will travel up to 9 m in air and about 10 mm in water.



Beta radiation shielding



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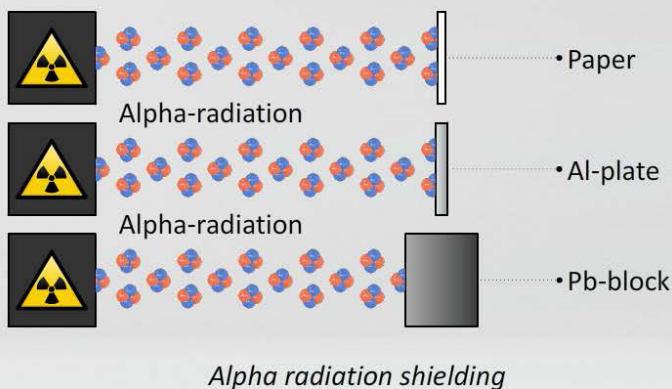
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Mechanism of interaction of alpha radiation with matter

Since alphas are low in penetration ability, they themselves are usually not hazardous for external exposure, unless the alpha-emitting nuclide is deposited to organism. A sheet of paper, the surface layer of dead skin (epidermis), or a few centimeters of air can easily stop alpha particles. When internally deposited, alpha particles are often more damaging than most other types of particles because comparatively large amounts of energy are deposited within a very small volume of tissue.



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1/20. The mathematical expression for the law of radioactive decay (τ – the mean lifetime, λ – the decay constant) is:

- $N(t) = N_0 \exp\left(\frac{t}{\tau}\right)$
- $N(t) = N_0 \exp\left(-\frac{t}{\tau}\right)$
- $N(t) = N_0 \exp\left(-\frac{t}{\lambda}\right)$
- $N(t) = N_0 2^{-\frac{t}{\tau}}$

WRONG !

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Practicum

- ▶ **Lab 2.1** Study of signals from a pulse generator
- ▶ **Lab 2.2** Spectrum registration of scintillation detector with the NaI crystal



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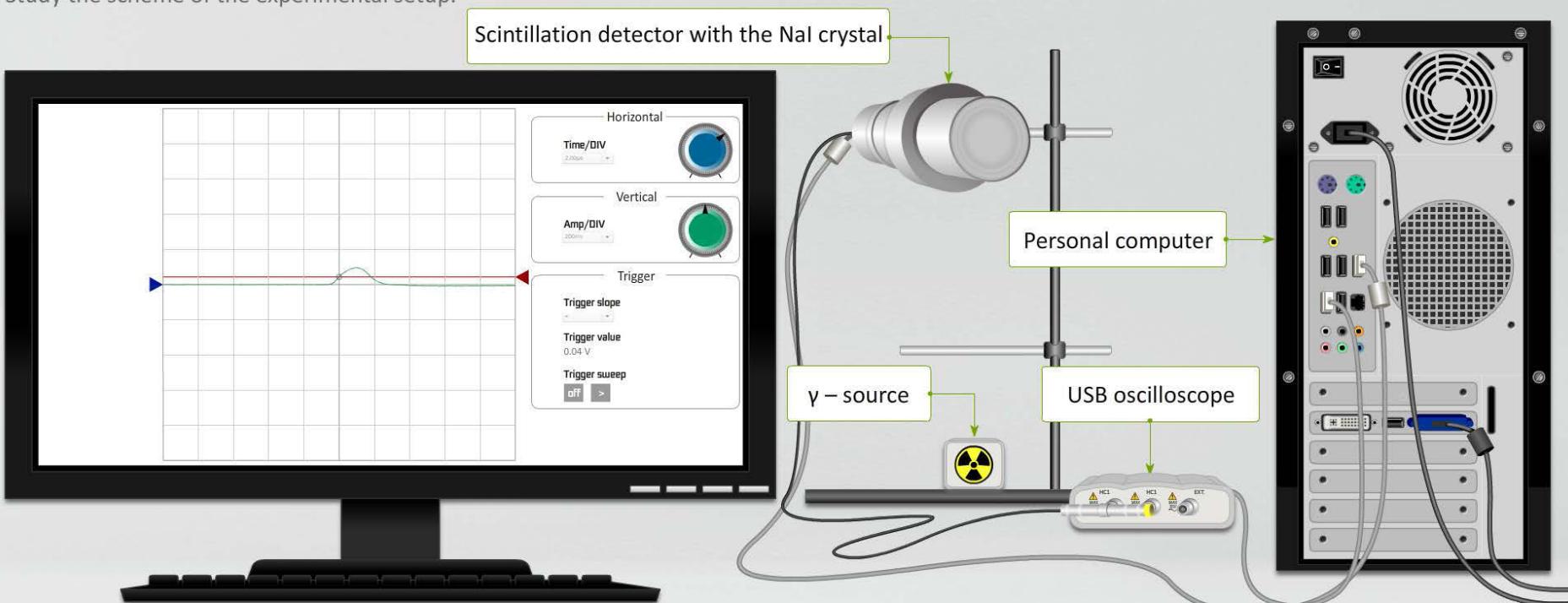
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Laboratory work 2.2

Spectrum registration of scintillation detector with the NaI crystal

Study the scheme of the experimental setup.



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[?] [] [next]

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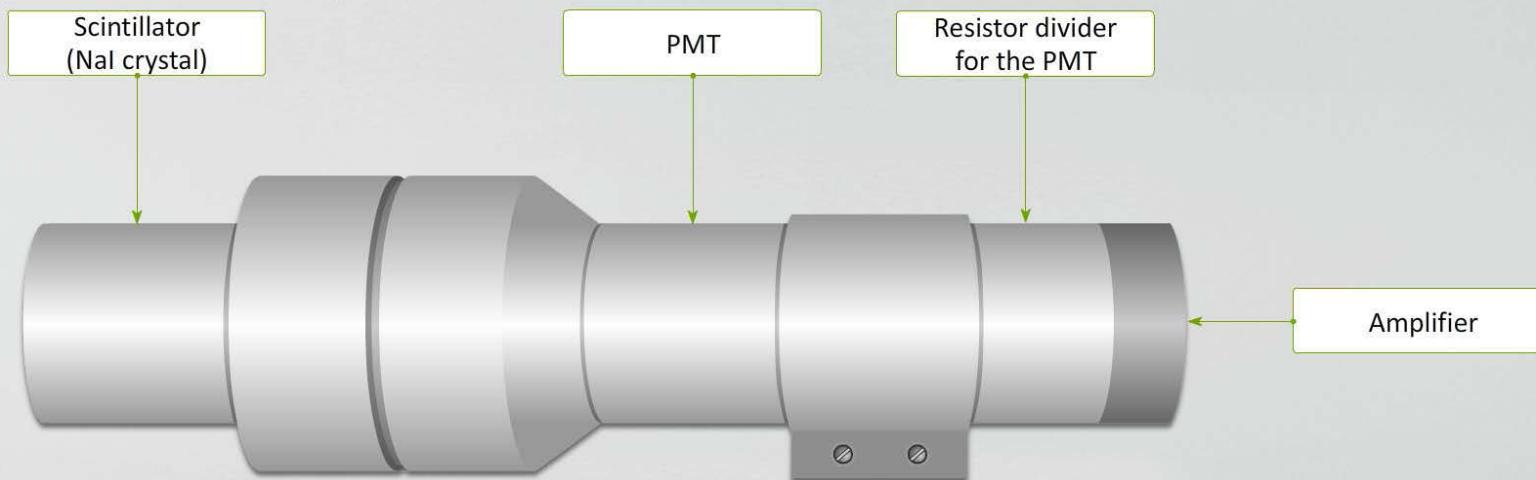
Laboratory work 2.2

Spectrum registration of scintillation detector with the NaI crystal



The scintillation gamma detector consists of:

- an inorganic scintillator (NaI crystal), in which ionizing particles cause a burst of luminescence;
- a photomultiplier tube (PMT), that converts a light flash into the pulse of electric current;
- a resistor divider for the PMT, that allows to supply the proper operating high voltage distribution to the PMT;
- an amplifier, that amplifies the electric pulse from the PMT.



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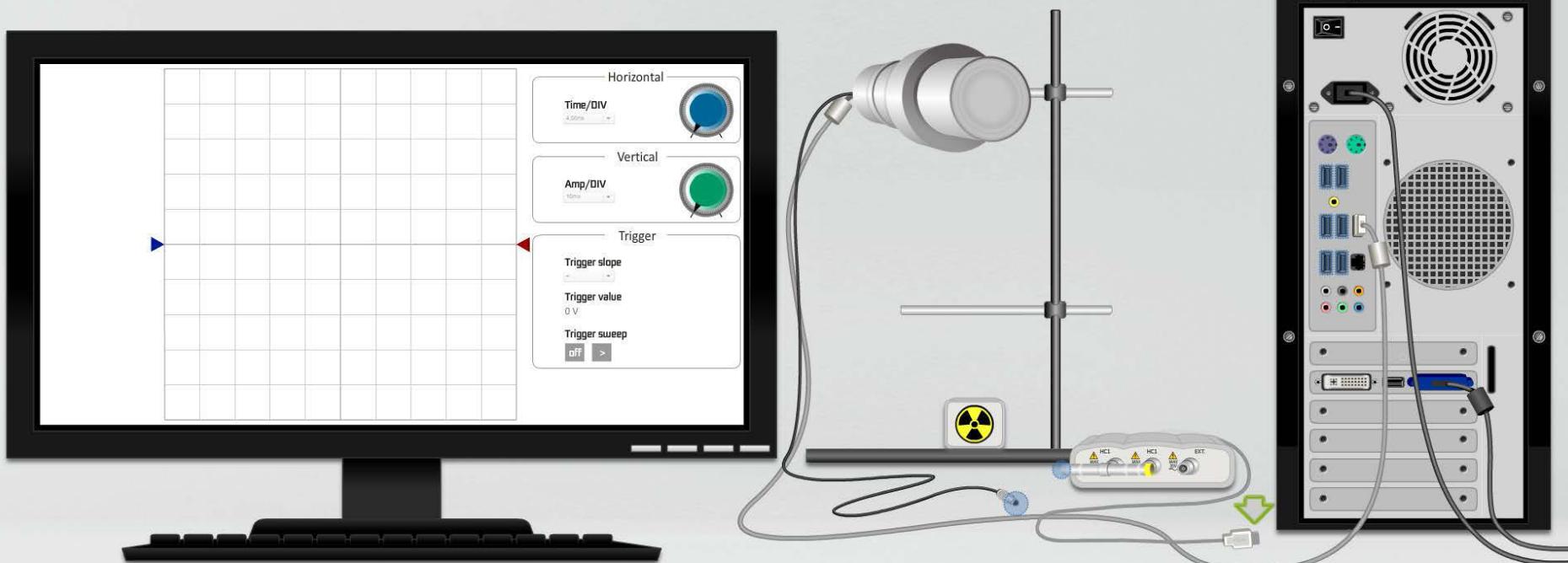
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Laboratory work 2.2

Spectrum registration of scintillation detector with the NaI crystal



Connect the USB oscilloscope with the scintillation detector and with the personal computer. Using the oscilloscope interface settings find the signal from the detector.



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[?] [next] [exit]

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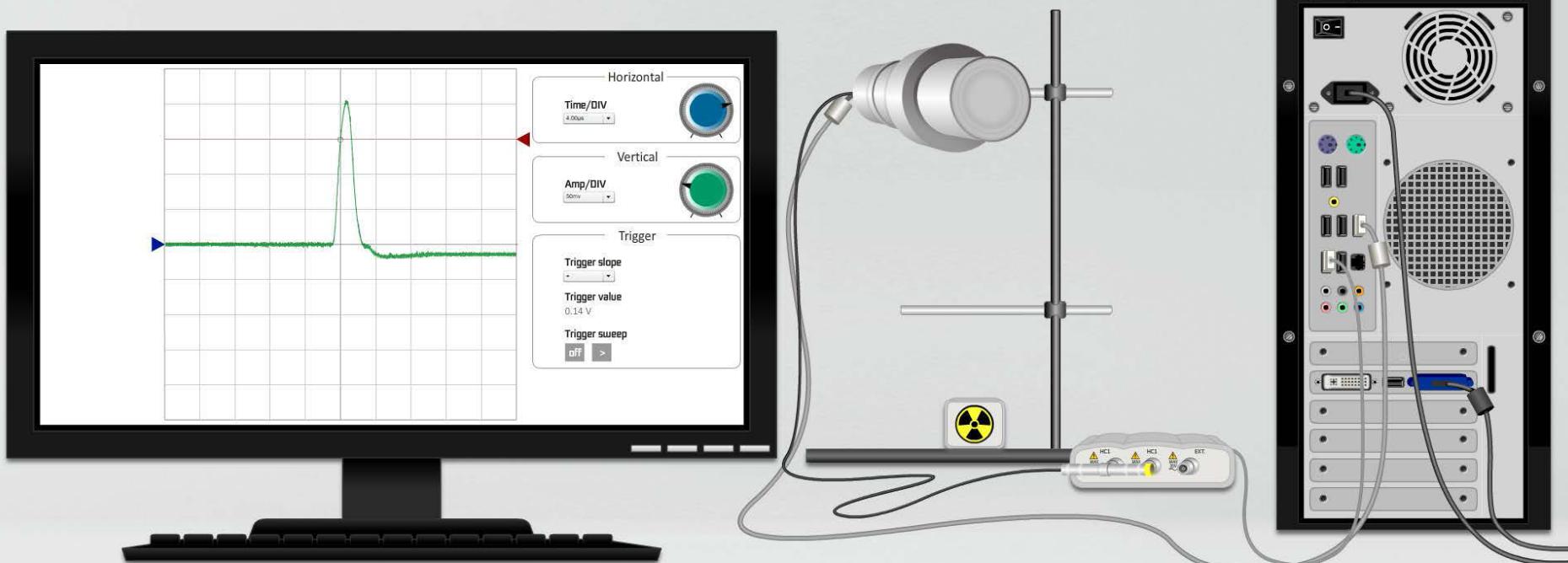
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Laboratory work 2.2

Spectrum registration of scintillation detector with the NaI crystal

Connect the USB oscilloscope with the scintillation detector and with the personal computer. Using the oscilloscope interface settings find the signal from the detector.



[] [] []

WELL DONE!

[] [] []

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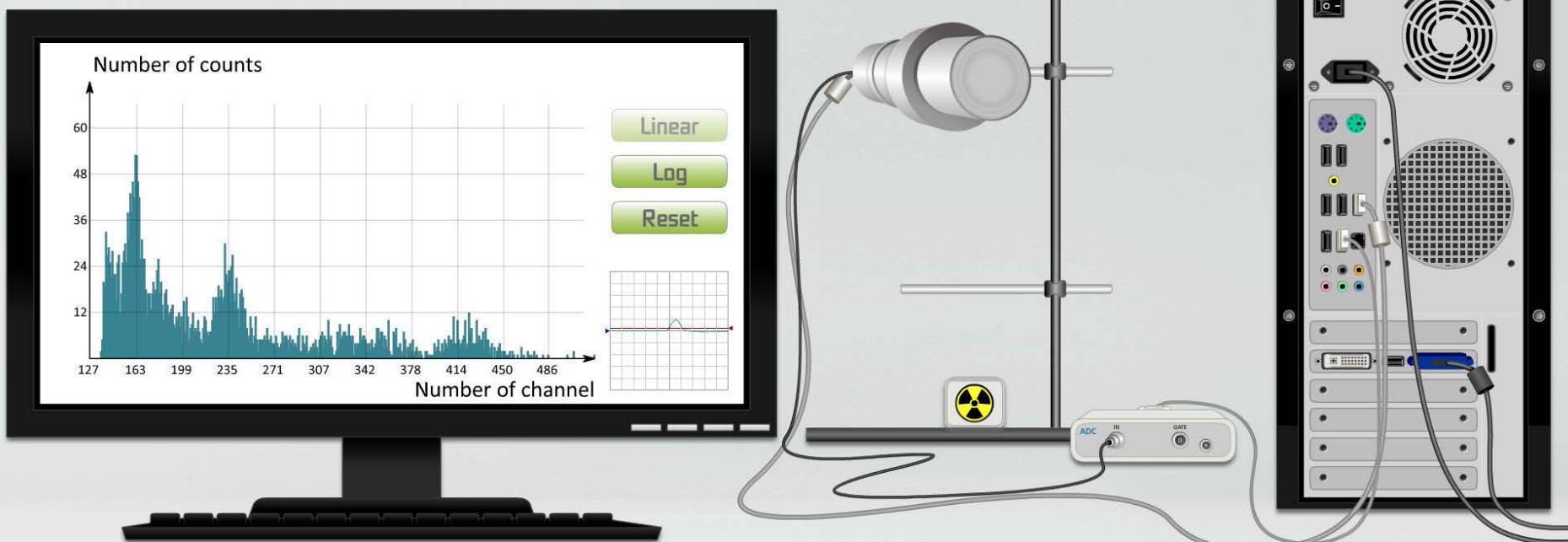
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Laboratory work 2.2

Spectrum registration of scintillation detector with the NaI crystal



Connect the ADC with the scintillation detector and with the personal computer. Study how the picture from the oscilloscope corresponds with the amplitude spectrum collection.



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[?] [next]

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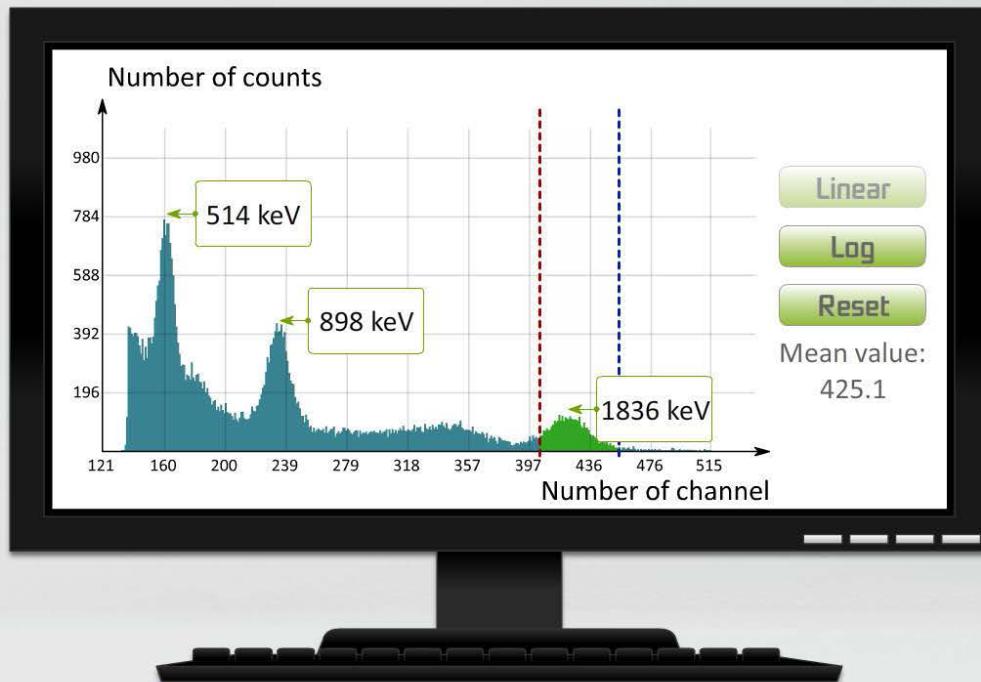
Introducere în laboratorul virtual

Laboratory work 2.2

Spectrum registration of scintillation detector with the NaI crystal



There is the spectrum from the gamma source. Find centers of gravity of 3 designated peaks. Move the blue and the red cursors to limit the area of the peak you wish to study and see «Mean value». Fill the table with calculated values (round values to 1 decimal place).



Mean value, channel	Energy, keV
162.2	514
236	898
425.1	1836

WELL DONE!

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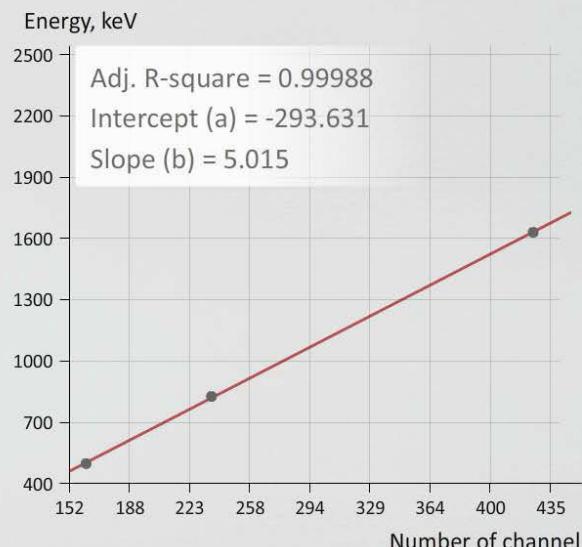
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Laboratory work 2.2

Spectrum registration of scintillation detector with the NaI crystal



Build the graph of the obtained dependency.



Mean value, channel	Energy, keV
162.2	514
236	898
425.1	1836

$$\text{Energy} = -293.631 + 5.015 \cdot \text{Channel number}$$

The obtained slope and intercept are the coefficients of the linear calibration of the energy scale of the PIN diode.

[] []

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How to Measure Radioactivity

Practicum

 **Lab 2.1** Study of signals from a pulse generator

 **Lab 2.2** Spectrum registration of scintillation detector with the NaI crystal



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1. Introduction
2. Radioactive Sources
3. Interaction of Radiation with Matter
4. Interaction of Charged Particles with Matter
5. Radiation Detectors:
 - Gas-Filled Detectors
 - Scintillation Detectors
 - PIN Diodes
 - Detectors Based on Microchannel Plates
6. Measurement of Radioactivity
7. Quiz
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Calculator

CE		←		
7	8	9	-	%
4	5	6	x	1/x
1	2	3	+	/
0	+/-	.	=	

PASTE

SAVE

PDF

UNDO

CLEAN

Text

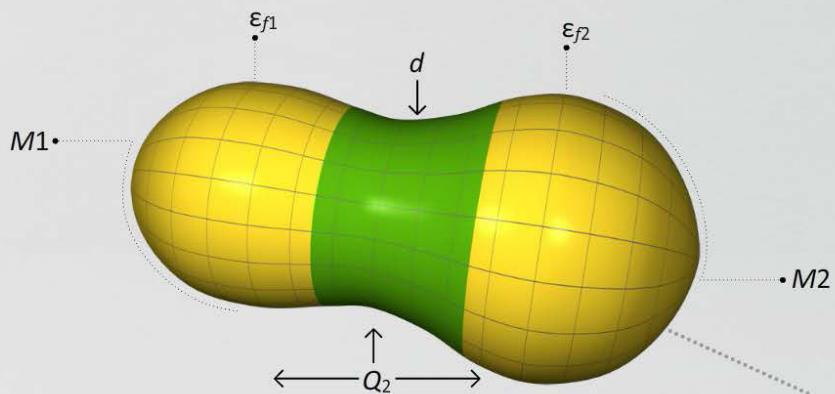
+

5. <http://v-labs.ru/>

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Introducere în laboratorul virtual

Theoretical Models of the Atomic Nucleus



ϵ_{f1} — Left fragment deformation
 ϵ_{f2} — Right fragment deformation
 d — Neck
 Q_2 — Elongation (fission direction)
 $\alpha_g = (M_1 - M_2)/(M_1 + M_2)$ Mass asymmetry



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2. Nuclear Models
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 - Fermi Gas Model
 - Shell Model
 - Collective Model
3. Quantum Mechanics in Nuclei
4. Fission and Quantum Tunneling
5. Basic Regularities of Spontaneous Fission
6. Collinear Cluster Tri-Partition (CCT)
7. Quiz
8. Exercises

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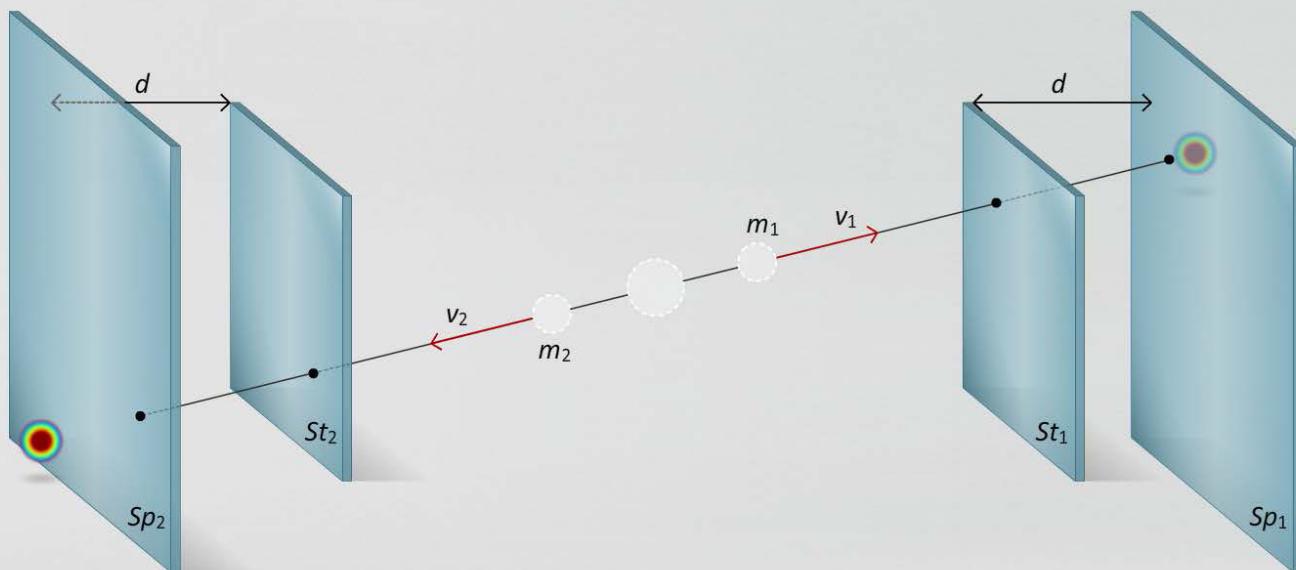
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Nuclear Fission Experiment



1. Introduction
2. Physics of Binary Fission
3. Methods of Detection of Fission Fragments
4. Energy Measurements of Fission Fragments from Californium-252
5. Time Measurements of Fission Fragments
6. Quiz
7. Practicum

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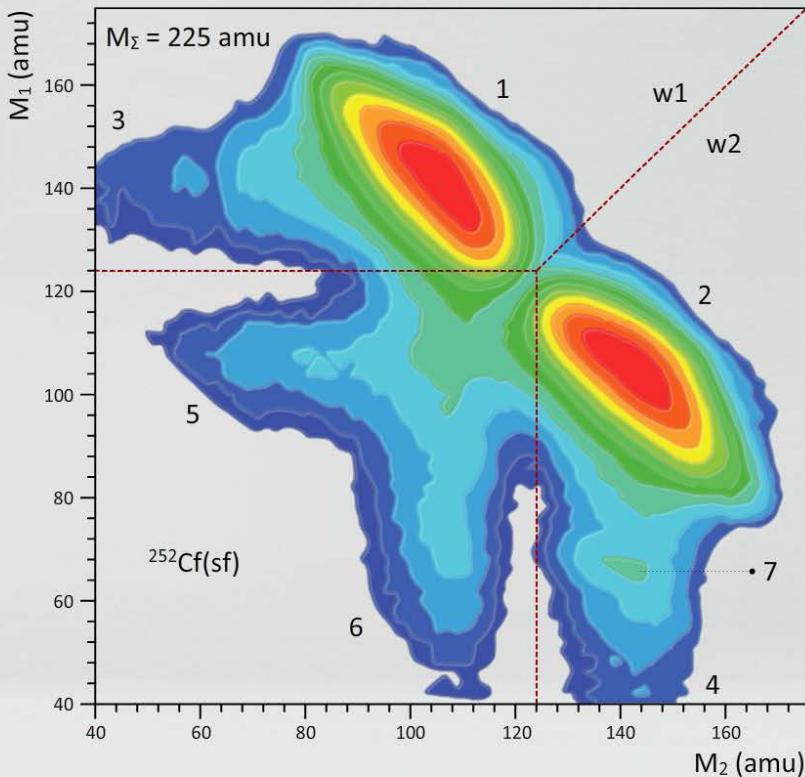
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Light Ions Spectrometer – Measurements



Virtual Laboratory

1. Physical Motivation
2. LIS Setup
3. Electronics of the LIS Setup
4. Block Diagram and Data Acquisition System
5. CAMAC Practicum
6. PIN Diode Calibration
7. Time of Flight Calibration

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Light Ions Spectrometer – Data Analysis



Virtual Laboratory



ROOT
Data Analysis Framework

1. Introduction
2. Data Viewer
3. Preparation to Time Calibration
4. Time Calibration
5. Preparation to Energy Calibration
6. Energy Calibration
7. Mass Calculation

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Introducere în laboratorul virtual

Light Ions Spectrometer – Data Analysis

Introduction

ROOT is a modular scientific software framework. It is realized as a set of class libraries. It provides all the functionalities needed to deal with big data processing, statistical analysis, visualization and storage. Components of ROOT includes the following:

- histogram, diagram and function building;
- image processing;
- data storage;
- data sorting;
- simple modeling;
- parallel processing (PROOF);
- using of neural networks.

References:

Site – <https://root.cern.ch/>

User manual – <https://root.cern.ch/root-user-guides-and-manuals>

Reference guide – <https://root.cern.ch/doc/master/index.html>

"HowTo" – <https://root.cern.ch/howtos>



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6. Energy Calibration
7. Mass Calculation

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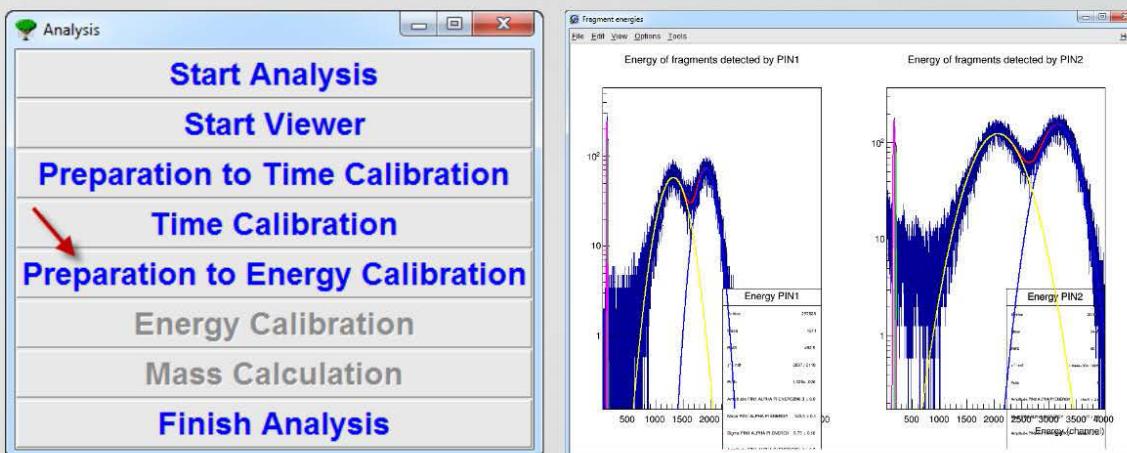
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Light Ions Spectrometer – Data Analysis

Preparation to Energy Calibration

Start preparation of energy calibration in ROOT

Press the button "Preparation to Energy Calibration" and study the diagrams.



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2. Data Viewer
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4. Time Calibration
5. Preparation to Energy Calibration
6. Energy Calibration
7. Mass Calculation

Diagram description

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Light Ions Spectrometer – Data Analysis



Energy Calibration

Start energy calibration in ROOT

Press the button "Energy Calibration" and study the diagram.

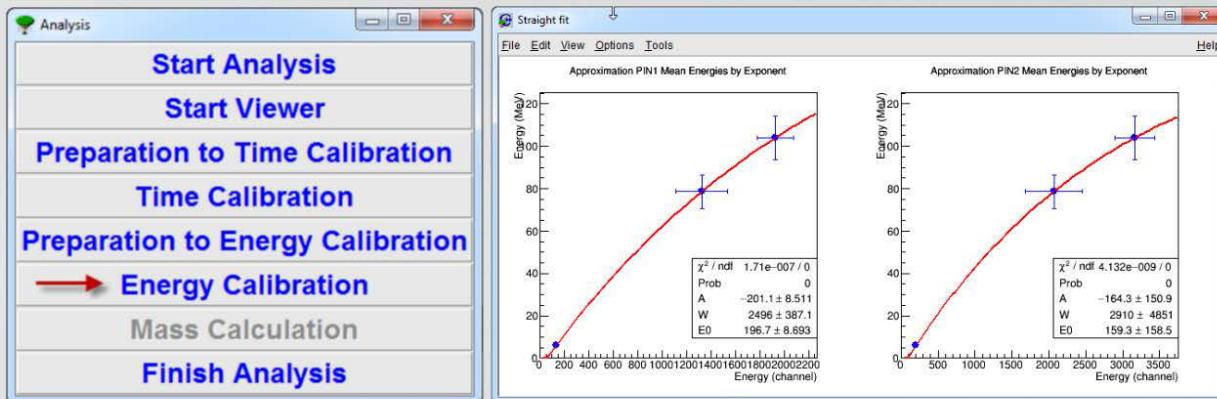


Diagram description

The diagram shows the fitting of three points by the formula 1. See details in Preparation to Energy Calibration.

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Light Ions Spectrometer – Data Analysis



Mass Calculation

Start mass calculation in ROOT

Press the button "Mass Calculation" and study the diagram.

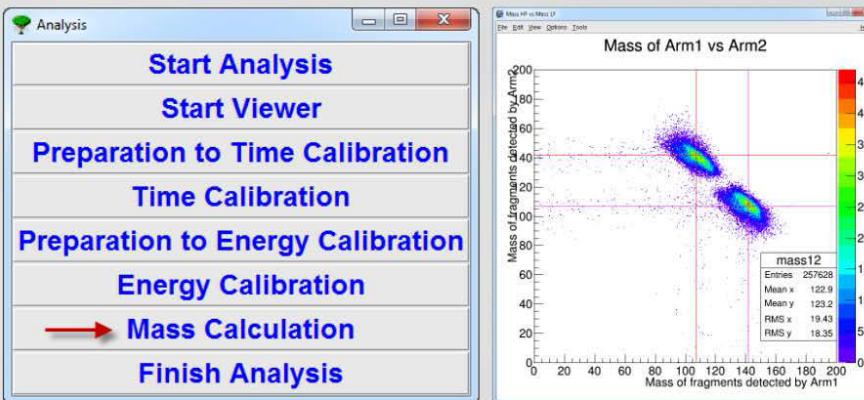


Diagram description

The diagram shows the mass-mass distribution of $^{252}_{\text{Cf}}$ fission fragments in the arm #1 vs arm #2. Two

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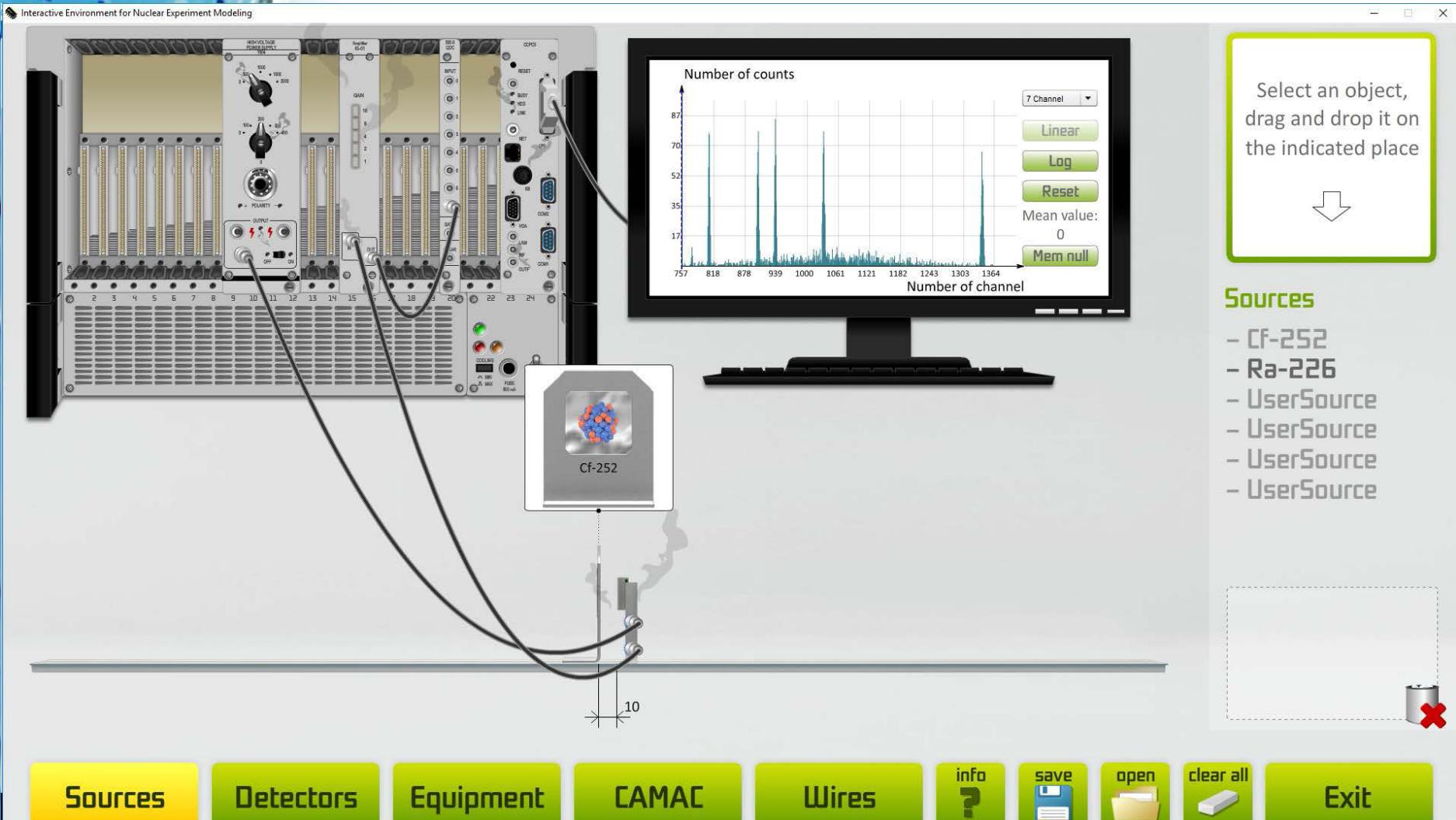
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Introducere în laboratorul virtual





Prompt-gamma neutron activation analysis in mining.

*Frank Laboratory of Neutron Physics
Joint Institute for Nuclear Research*



engineer, Constantin Hramco
costea.edinets@mail.ru

In order to perform the objective, first step is to evaluate the accuracy of HPGe in detecting of gamma-radiation from different elements. This task was reached by assembling the construction that is shown in Figures below:

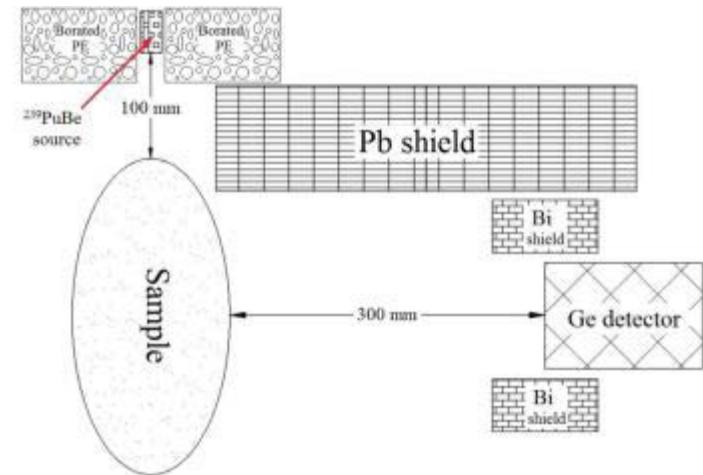


Figure 1. The scheme of assembly for determining the elemental content of phosphate ores.

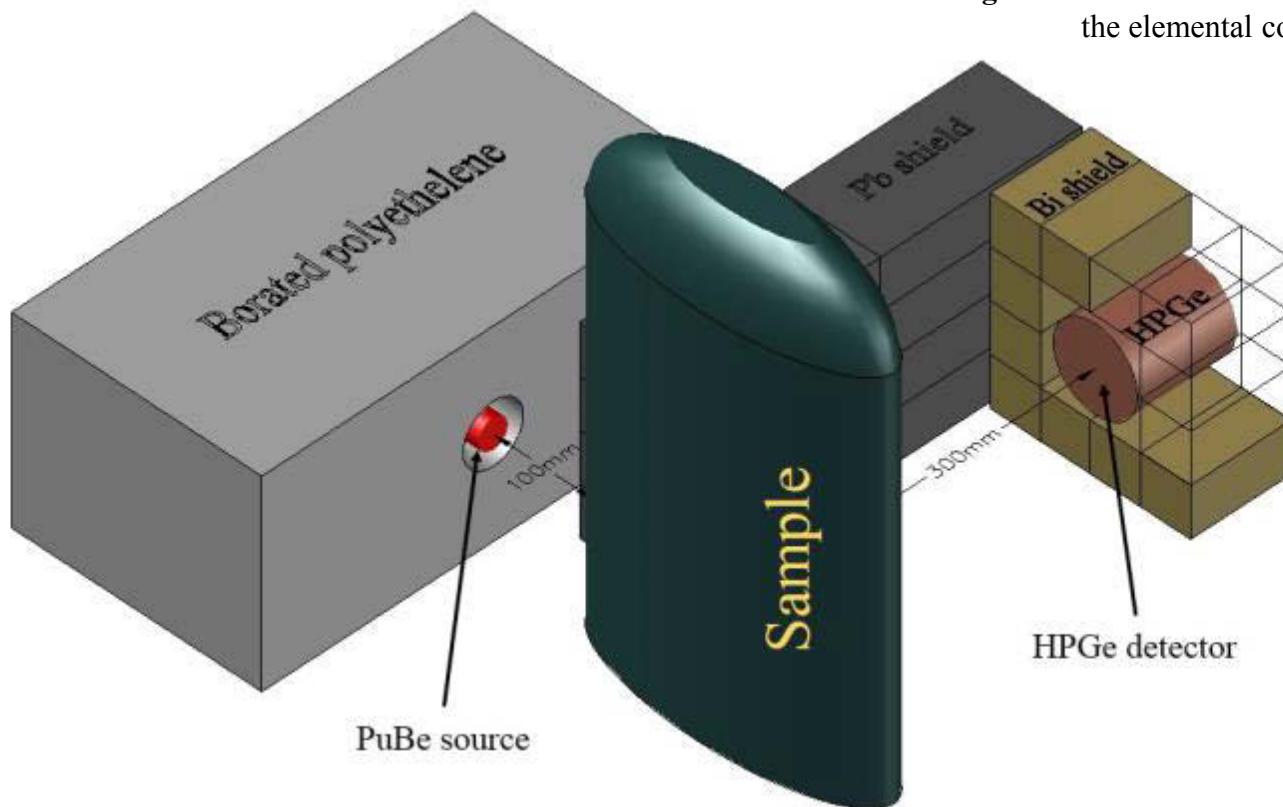


Figure 2. 3D-model of assembly for determining the elemental content of phosphate ores.

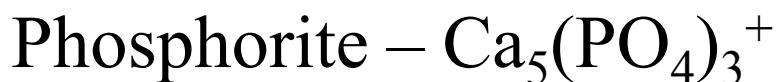
For experimental setup source of neutrons was chose ^{239}Pu -Be mixture with average neutron energy around 4.5 MeV. To detect gamma rays that are coming from interaction of neutrons with nuclei was set a Ortec high-purity germanium detector (HPGe) with the features presented in the table below:

Table 1. Main characteristics of Ortec HPGe gamma-detector.

	Certified	Measured
Resolution (FWHM) at 1.33 MeV, ^{60}Co	1.90 keV	1.90 keV
Relative Efficiency at 1.33 MeV, ^{60}Co	30%	36%



The sample is PET sac containing 10 kg of phosphate ore.

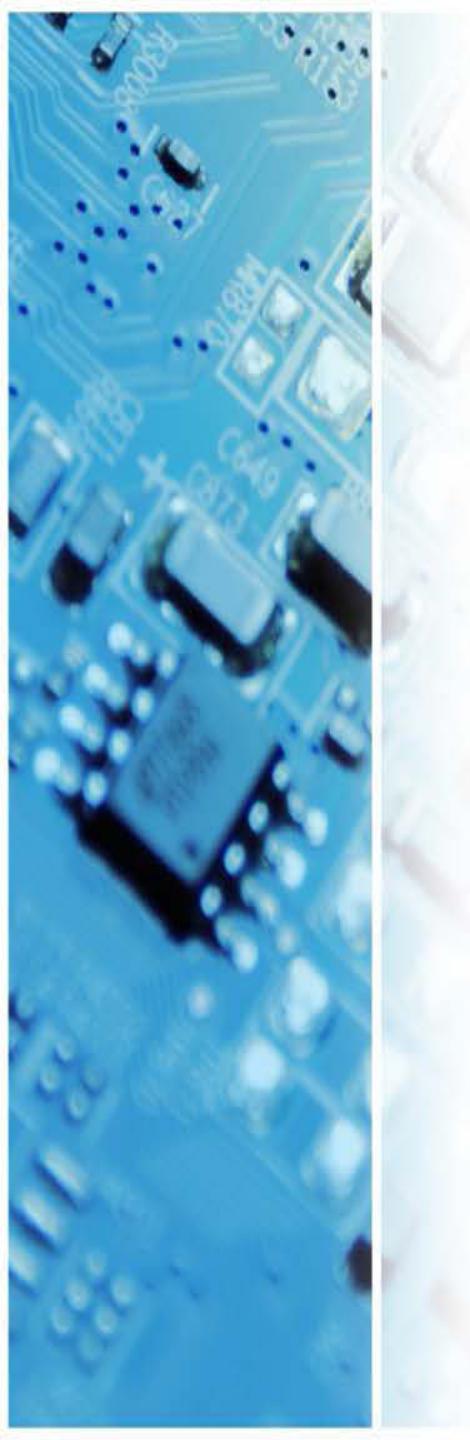


$$\omega(\text{Ca}) = 41.29\%$$

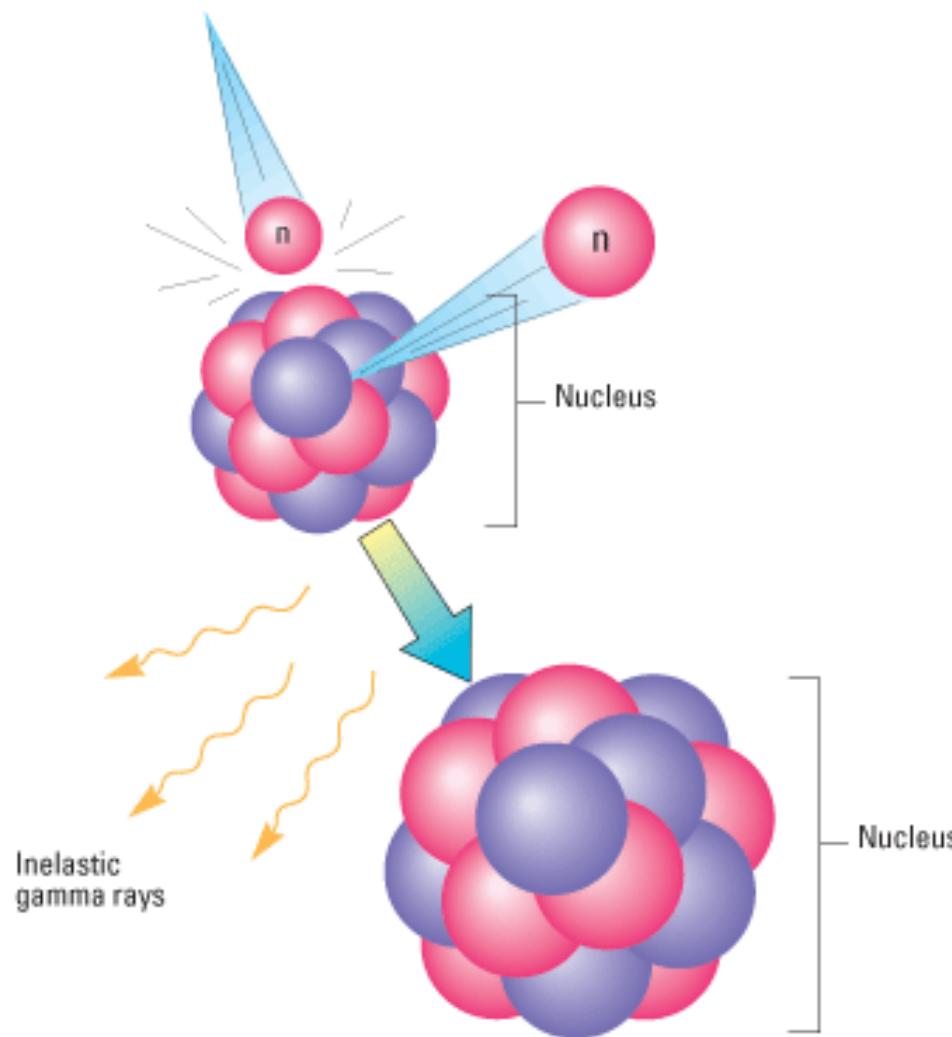
$$\omega(\text{CaO}) = 57.77\%$$

$$\omega(\text{P}) = 19.15\%$$

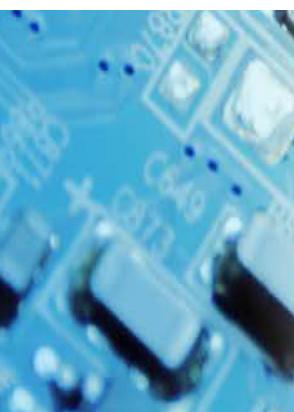
$$\omega(\text{P}_2\text{O}_5) = 43.87\%$$



Used reaction



Important step in work with any gamma-spectroscopy instrument is to have well done channel-energy calibration. In our case the calibration was performed by two methods: by standard point sources (^{60}Co & ^{137}Cs) and by irradiation of metal samples (Cd & Pb).



^{60}Co : 1173.2 and 1332.5 KeV
 ^{137}Cs : 661.7 KeV

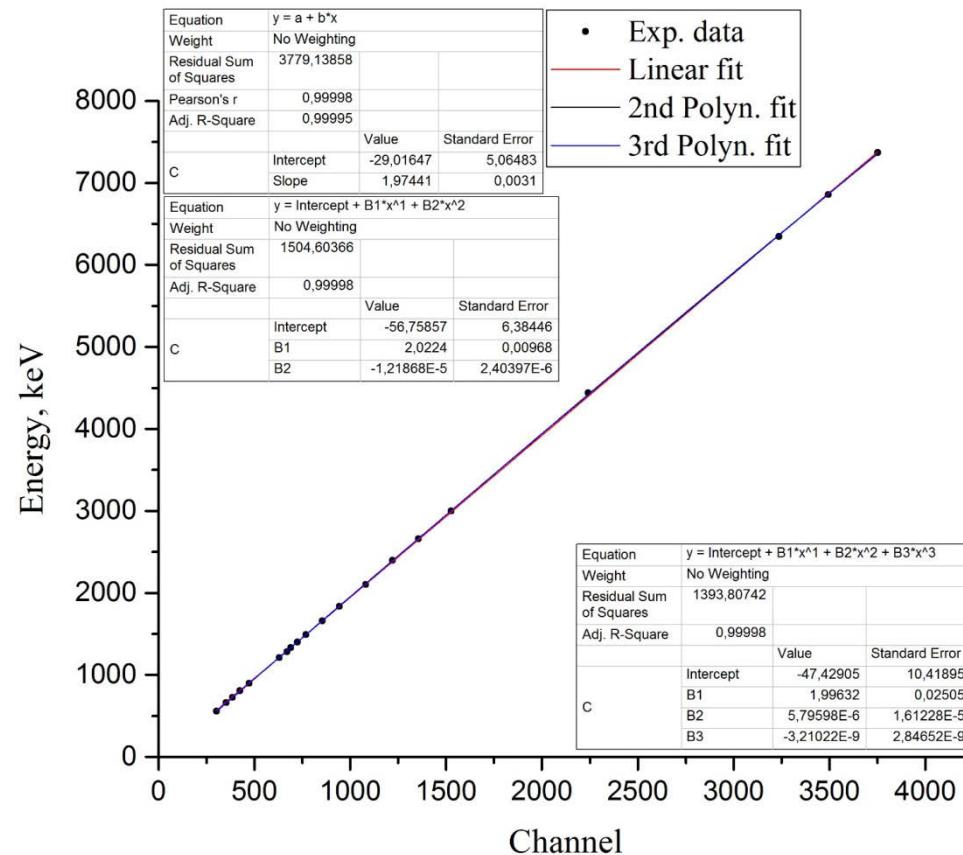


Figure 3. HPGe Channel-Energy calibration curve.

The data acquisition was done by COCOS (COmbedded Correlation System) program developed at JINR FLNP, data processing was performed by Canberra's Genie™ 2000 program. As an example, in the figure below is shown the comparison between gamma-spectra from three irradiated samples (concentrate – black, tails – red, mixture – purple) and background (blue):

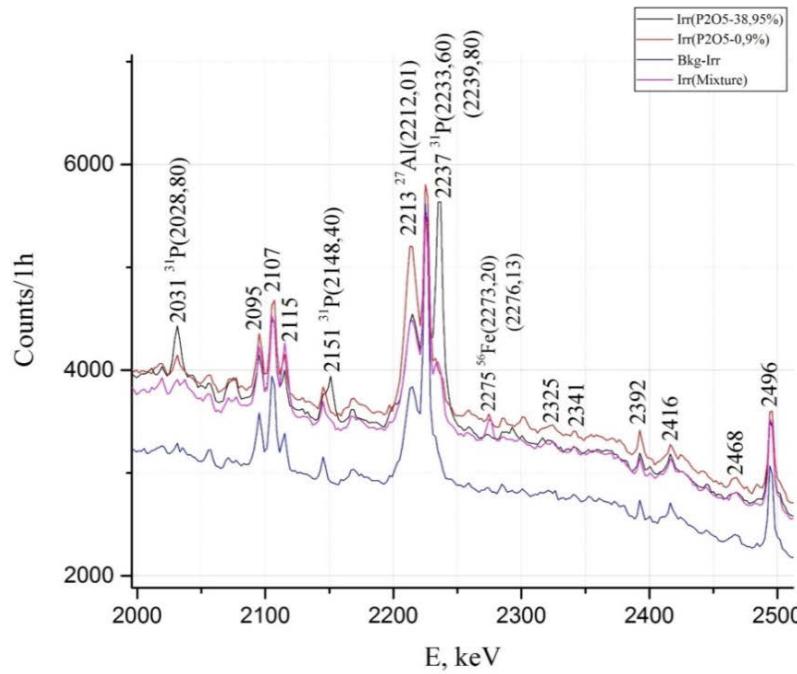


Figure 4. Part of gamma-ray energy spectrum (2.0-2.5 MeV).



Acknowledgement

D. N. Grozdanov F. A. Aliyev

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V. M. Bystritsky I. N. Ruskov

S. B. Borzakov V. R. Skoy

NAA a probelor arheologice



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NAA a probelor arheologice



Fig.1. Proba №1 pînă la curătire



Fig.2. Proba №2 pînă la curătire

Procesarea probelor arheologice:

1. Curătarea de impurități exterioare a probelor osoase – cu apă distilată și alcool, a probei de păr – cu acet.
2. Mărunțirea probelor în mojar din agat,
3. Uscarea probei pînă la masă constantă.
4. Ambalarea.



Fig.4. Proba №2 după curătire

NAA a probelor arheologice

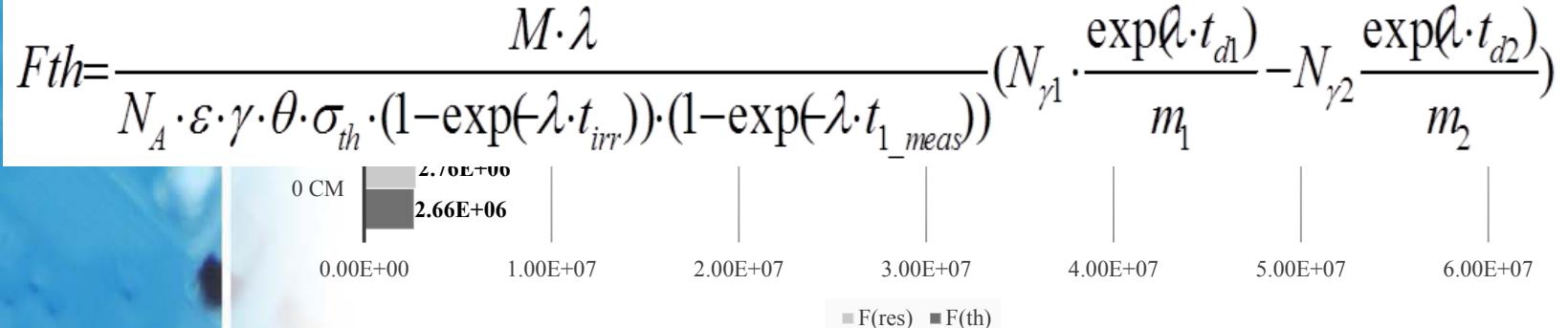


Fig.5. Probele analizate și standartele ambalate în containere de plastic pentru iradierea la insulație IREN
 Fig.6. Probele analizate și standartele ambalate în containere de plastic pentru iradierea la rectorul IBR-2

NAA a probelor arheologice

*Gradientul de răspîndire a neutronilor în
dependență de înălțimea țintei instalației IREN*

$$F_{res} = \frac{N \cdot M \cdot \lambda \cdot e^{\lambda t_{2_decc}}}{m_{2_p} \cdot N_A \cdot \gamma \cdot \varepsilon \cdot \theta \cdot I_{res} \cdot [1 - \exp(-\lambda t_{irr})] \cdot [1 - \exp(-\lambda t_{2_meas})]}$$



NAA a probelor arheologice

Tab. 1. Partea de masă a arseniului și mercurului în probele analizate

№	Arseniu (As)		Mercur (Hg)	
	p. de masă, mg/kg	eroare, %	p. de masă, mg/kg	eroare, %
1	0,19	30	0,36	19,1
2	0,23	30	0,2	29,5
3	1,18	18,3	46,6	2,5

Tab. 2. Partea de masă a arseniului și mercurului în probele de păr și cele osoase ale oamenilor contemporani

Proba	p. de masă As, mg/kg	p. de masă Hg, mg/kg
păr	$\leq 0,05$	$0,145 \pm 0,009$
oase	$< 0,1$	$\leq 0,008$

6. Analysis of Arsenic and Mercury Content in Human Remains of the 16th and 17th Centuries from Moscow Kremlin Necropolises by Neutron Activation Analysis at the IREN Facility and the IBR-2 Reactor FLNP JINR
T.D. Panova, A.Yu. Dmitriev, S.B. Borzakov, C. Hramco, Dubna 2017, ISSN 1547-4771, Physics of Particles and Nuclei Letters, 2018, Vol. 15, № 1, pp. 127–134.

Creșterea monocristalelor de naftalină

*Scopul: crearea țintei pentru polarizarea neutronilor
de eficiență înaltă*

7. Proton polarization above 70% by DNP using photo-excited triplet states, a first step towards a broadband neutron spin filter

T.R.Eichhorn, N.Niketic, B.van den Brandt, U.Filges, T.Panzner, E.Rantsiou, W.Th.Wenckebach, P.Hautle
Nuclear Instruments and Methods in Physics Research, Volume 754, 1 August 2014, Pages 10-14

8. The TRIPLE spin filter

P.P.J. Delheij, J.D. Bowman, C.M. Frankle, D.G. Haase, T. Langston, R. Mortensen, S. Penttila, H. Postma, S.J. Seestrom,
Yi-Fen Yen
Nuclear Instruments and Methods in Physics Research A 356 (1995) 120-121

9. High proton spin polarization with DNP using the triplet state of pentacene-d14

T.R. Eichhorn, M. Haag, B. van den Brandt, P. Hautle, W.Th. Wenckebach
Chemical Physics Letters 555 (2013) 296–299

10. ОБРАЗОВАНИЕ И РОСТ КРУПНЫХ МОНОКРИСТАЛЛИЧЕСКИХ ПЛАСТИН ДИФЕНИЛА И НАФТАЛИНА НА МЕЖФАЗНОЙ ГРАНИЦЕ ЖИДКОСТЬ-ВОЗДУХ

© 2013 В. А. Постников, КОНДЕНСИРОВАННЫЕ СРЕДЫ И МЕЖФАЗНЫЕ ГРАНИЦЫ, Том 15, № 2, С. 160—164

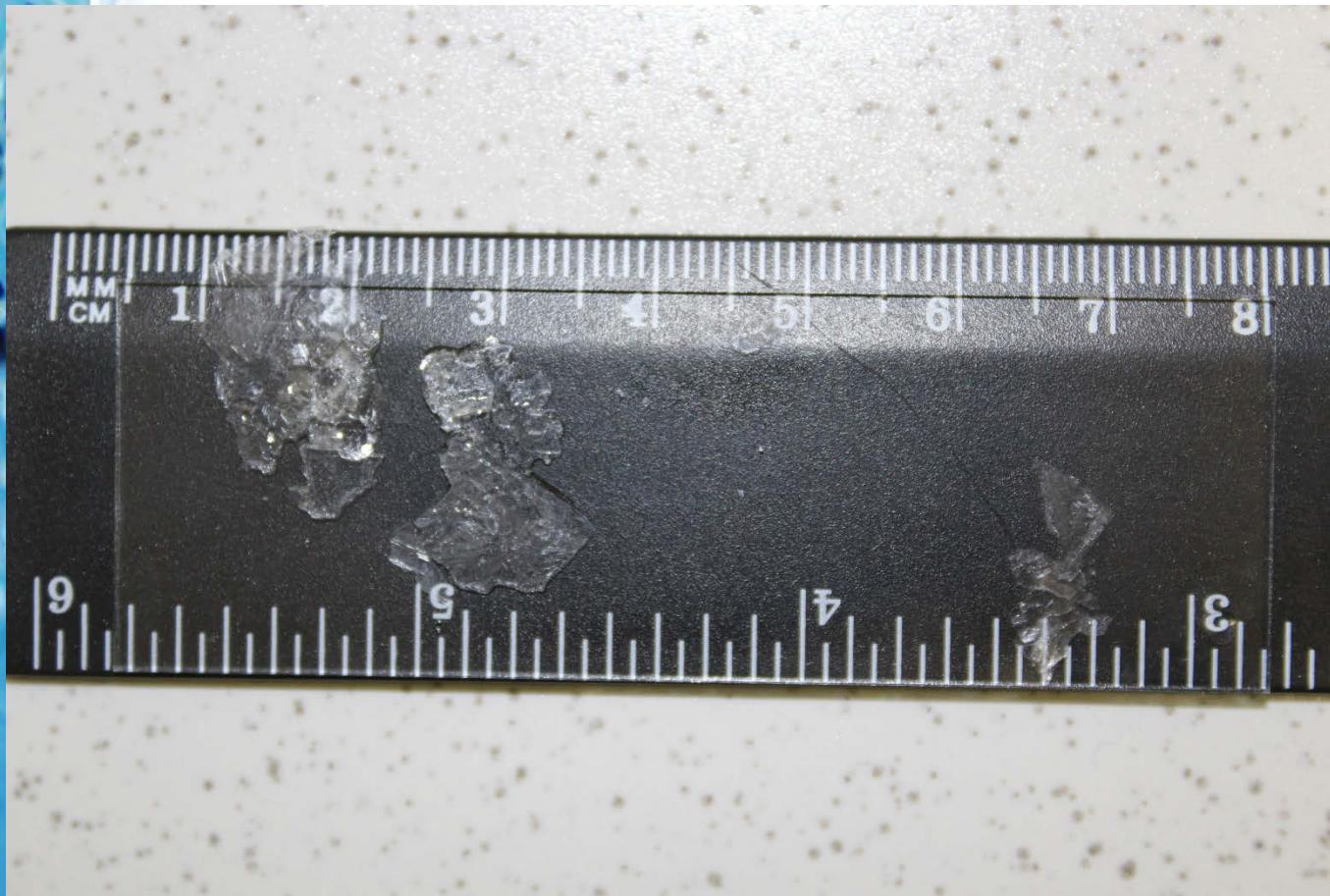
Creșterea monocristalelor de naftalină



Fig. 1
monocristale
ermetice
soluție

înerea
inchisă
rafață

Creșterea monocristalelor de naftalină



Activitate organizatorică, administrativă și Co-președinte al comitetului organizațional al școlii tinerilor cercetători și pedagogici IUCN, Lipnya-2017



Activitate organizatorică, administrativă și Participarea la proiecte pedagogice și popularizare a științei





*Vă mulțumesc mult pentru
atenție!*

*Va urez succes și
prosperitate!*