Greetings (Здравствуйте)

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Together in Excellence

DEVELOPMENT OF A PRACTICUM “TIME OF FLIGHT-ENERGY SPECTROMETER” FOR THE VIRTUAL LABORATORY

Project supervisors

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OUTLINE

- Aim of experiment
- Alpha particles and alpha decay
- Radium-226
- Time of flight-Energy (TOF-E) spectrometer
- Time of flight-energy spectrometer Detectors and experimental setup
- Time of flight-energy spectrometer experimental setup
- Results
- Data processing
- calculation of time and energy resolution
- Virtual lab
- conclusion

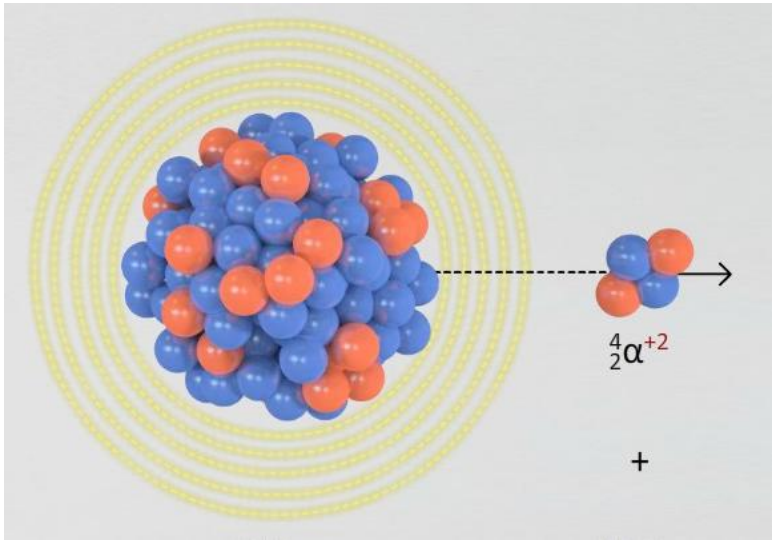
AIM OF PRACTICUM

The aim of this practicum is to show how the time of flight and energy spectrometer works.

ALPHA PARTICLES AND ALPHA DECAY

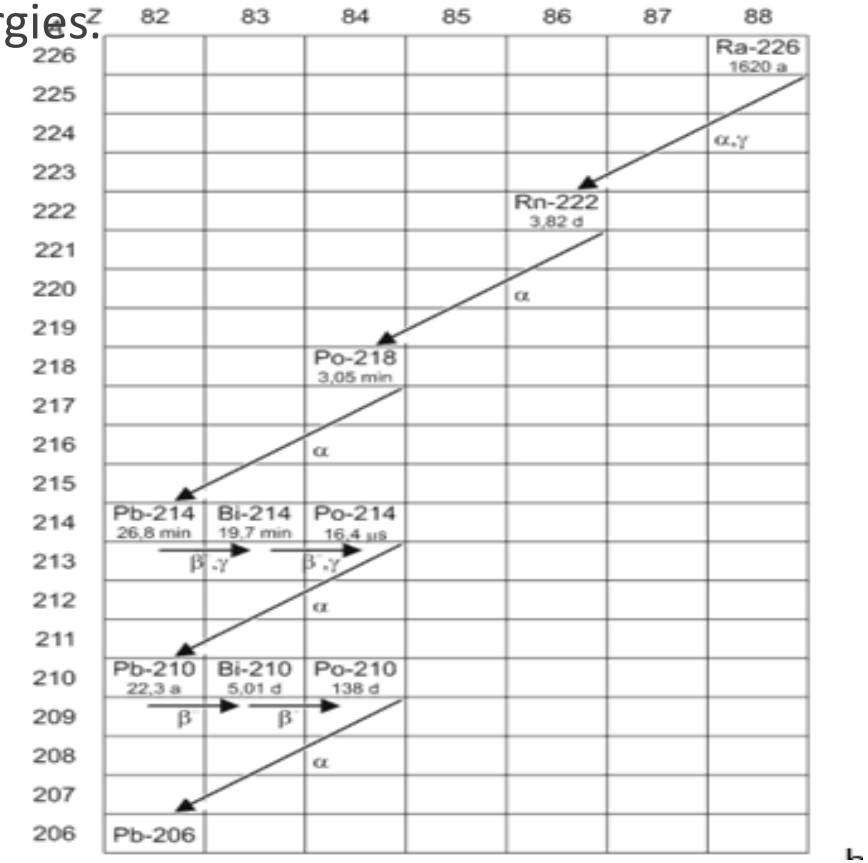
- **Alpha decay** – a radioactive process whereby a particle with two neutrons and two protons is ejected from the nucleus of an radioactive atom. The particle is identical to the nucleus of a helium atom, that particle is known as an alpha particle.

$$ {}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}X + {}^{4}_{2}\alpha \rightarrow {}^{A-4}_{Z-2}X + {}^{4}_{2}He^{2+} $$



RADIUM-226

Radium-226 decays mainly via alpha decay and emits 4 alpha particles of different observable energies.



Isotop	*Energy, MeV*	*relative intensity, %*
Ra 226	4.160	0.0002
Ra 226	4.191	0.0008
Ra 226	4.340	0.0066
Ra 226	4.601	5.9544
Ra 226	4.78434	94.038
Rn222	4.827	0.00055
Rn222	4.987	0.078
Rn222	5.48948	99.921
Po218	5.181	0.0011
Po218	6.00236	99.977
Pb214->β-,γ	*Bi214-> β-,γ*	*Po214*
Po214	6.6101	0.00006
Po214	6.9026	0.01057
Po214	7.68682	99.98937
Pb210->β-	*Bi210-> β-*	*Po210*
Po210	4.5167	0.0012
Po210	5.30433	99.9988

Time of flight-energy spectrometer

The time of flight-energy spectrometer uses two detectors, one as Start and one as Stop.

Start detector needs to be transparent to the particles and produce the trigger signal then particles flies through it.

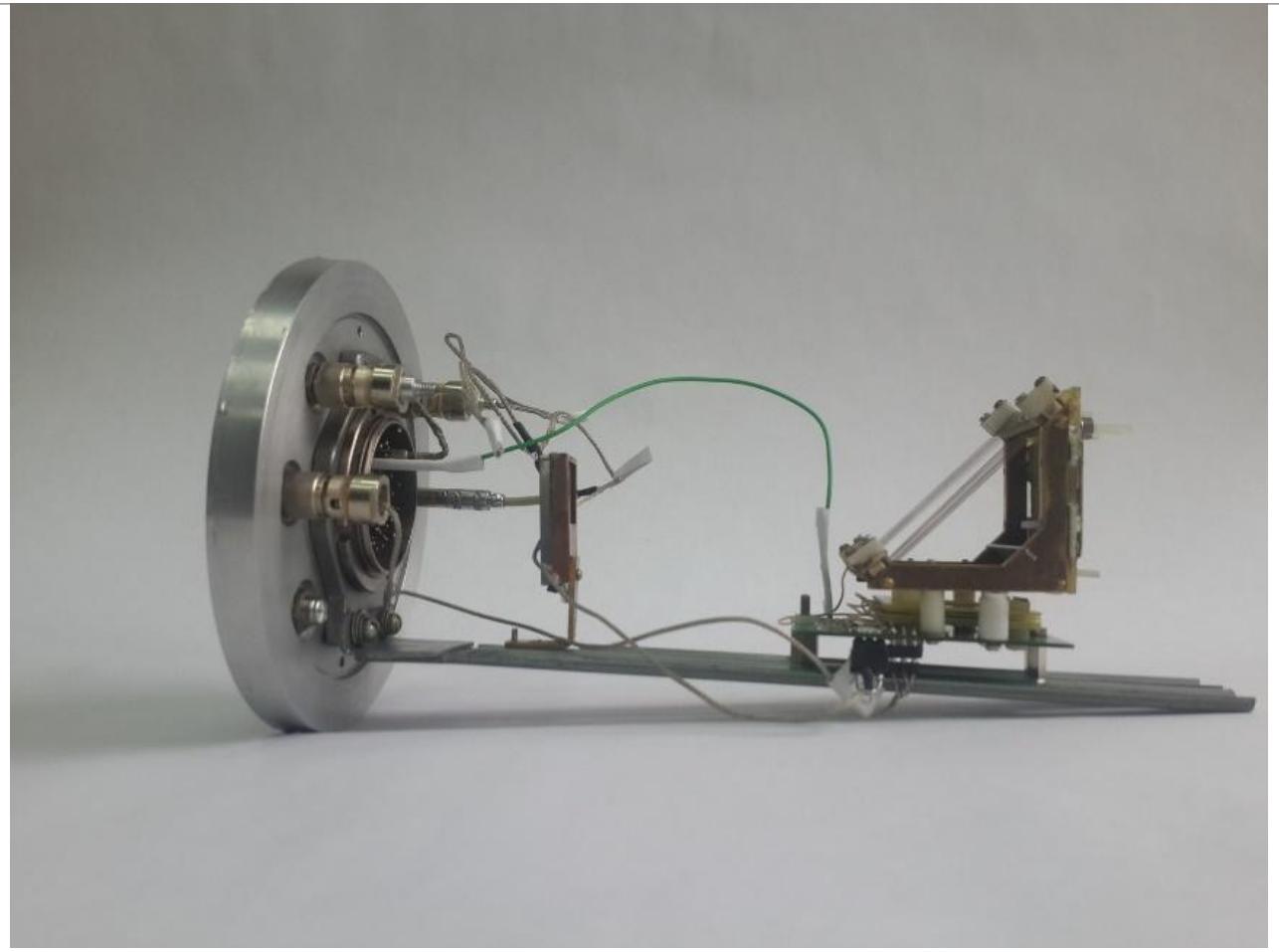
Stop detector measure the kinetic energy of the particles.

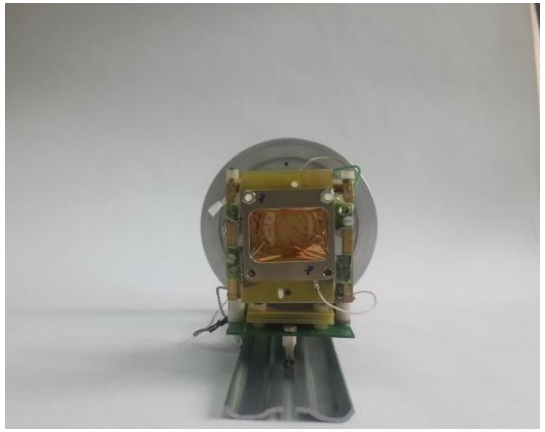
Knowing the distance between this two detectors it is possible to measure Time of Flight and calculate Velocity of the particle, so it is possible to calculate the mass of the particle using:

$$E = \frac{1}{k} m v^2, \text{ where k=2}$$

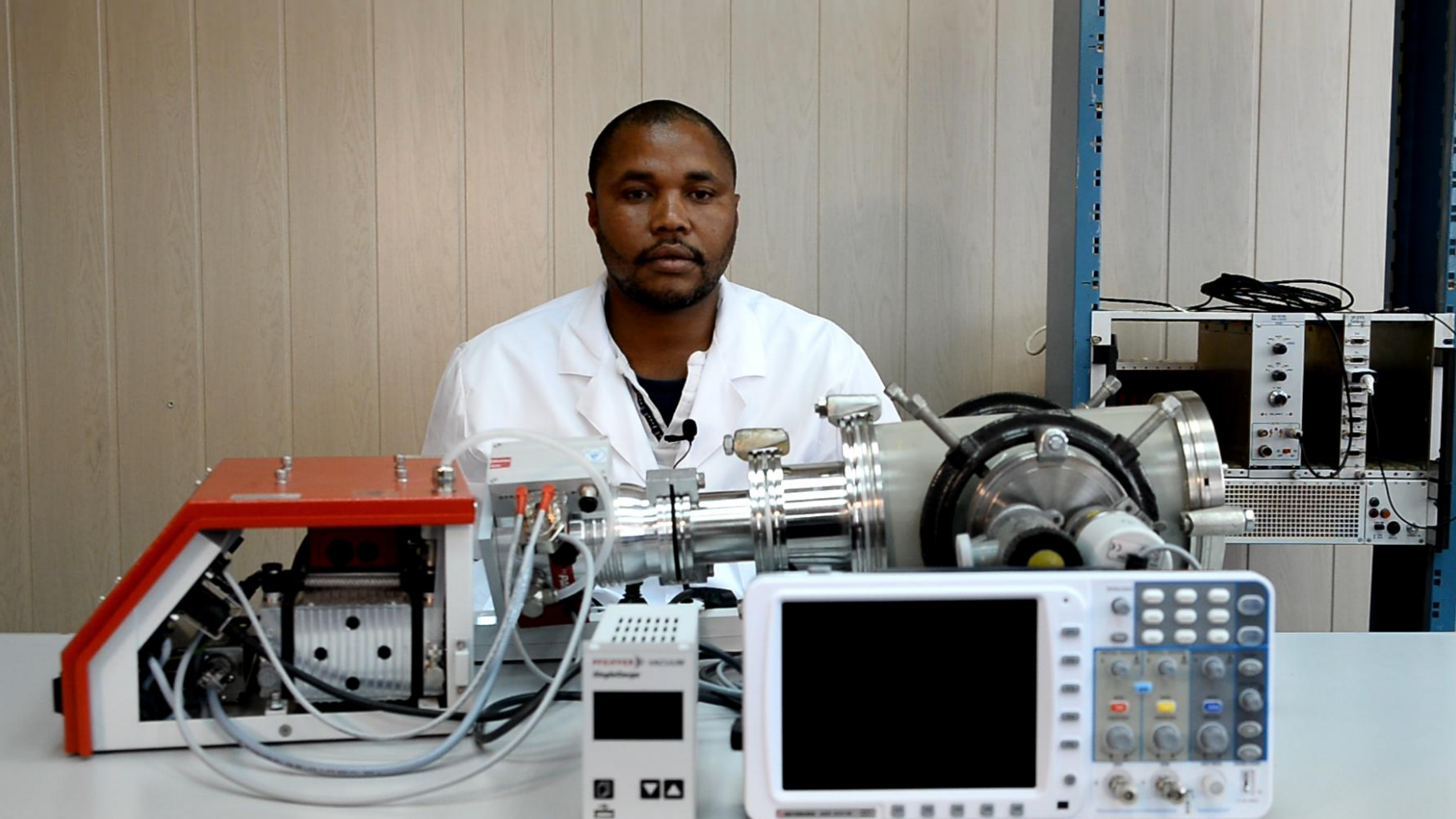
The specifics of this spectrometer is that it can work in a wide range of energy and mass (4 MeV-120MeV and 4 amu-150 amu respectively).

TOF-E spectrometer detectors

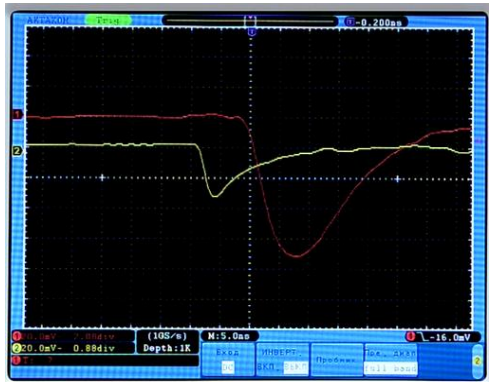


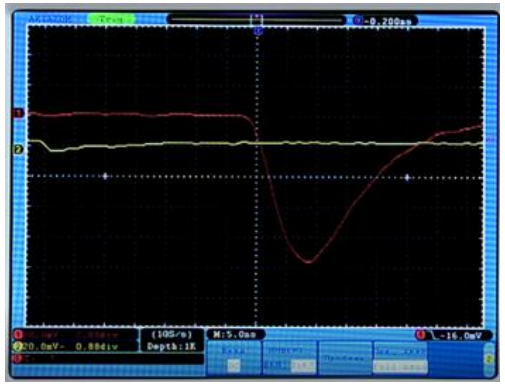


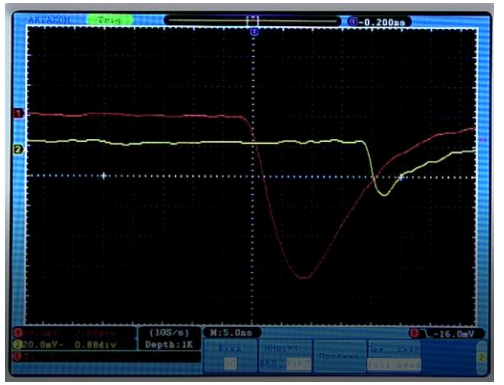
EXPERIMENTAL SETUP

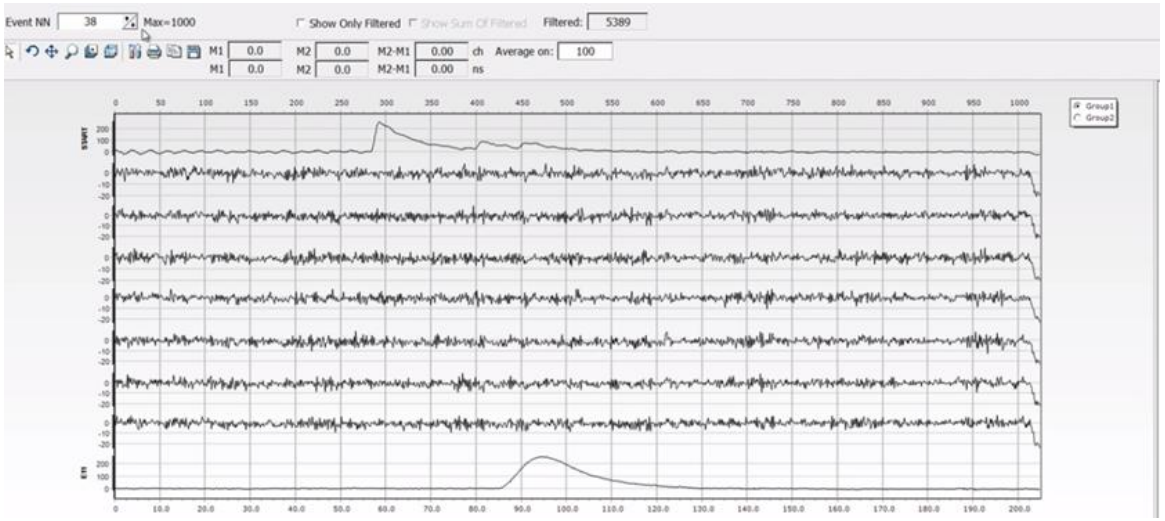


Results





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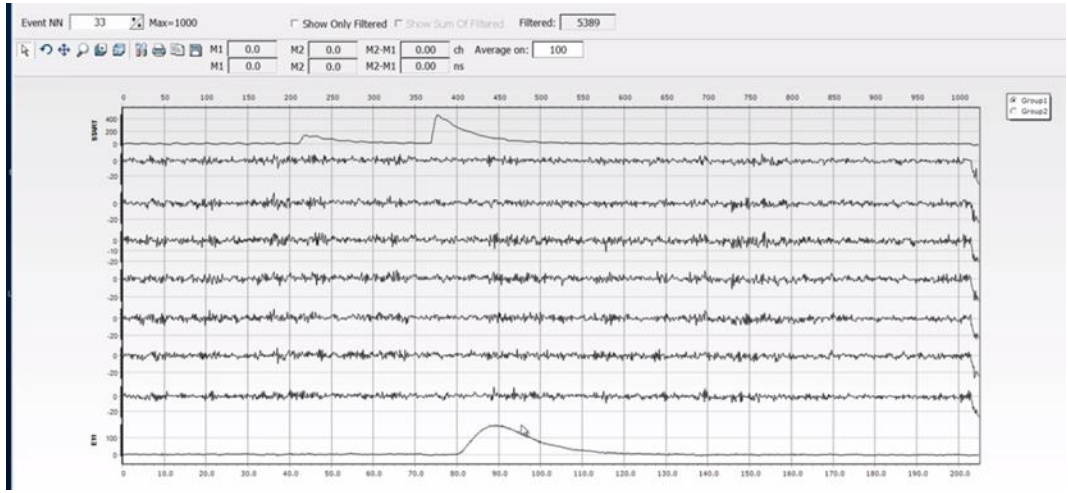
Filtered: 5389
M1 0.0 M2 0.0 M2-M1 0.00 ch Average on: 100
M1 0.0 M2 0.0 M2-M1 0.00 ns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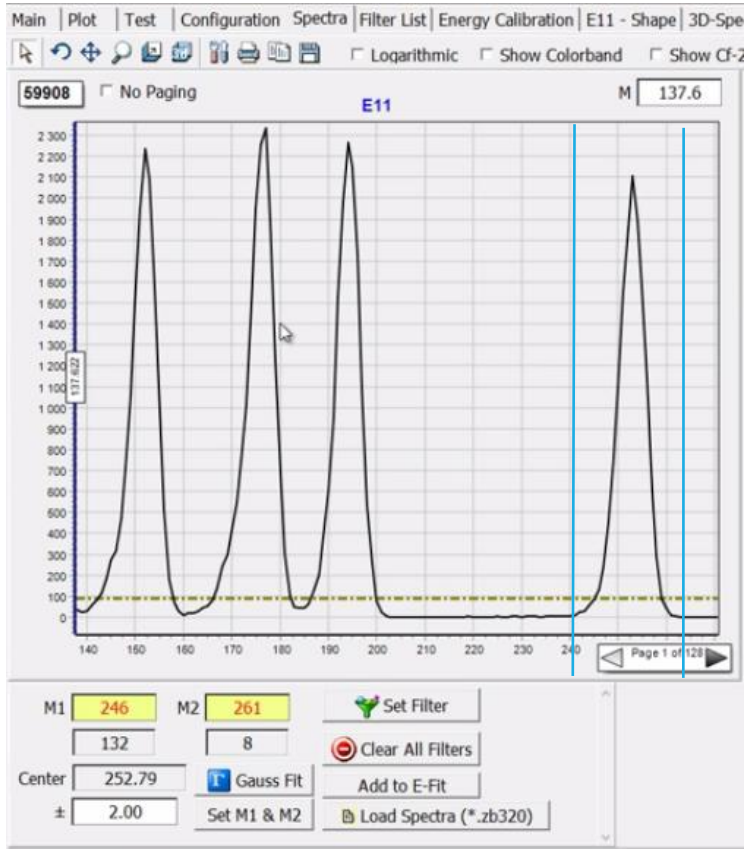
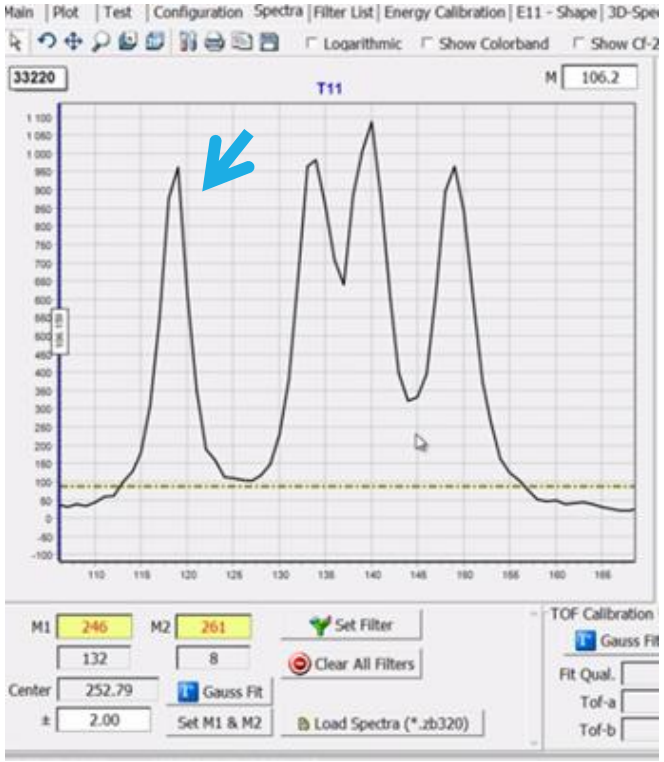
Show Only Filtered
Filtered: 5389
M1 0.0 M2 0.0 M2-M1 0.00 ch Average on: 100
M1 0.0 M2 0.0 M2-M1 0.00 ns

DATA PROCESSING

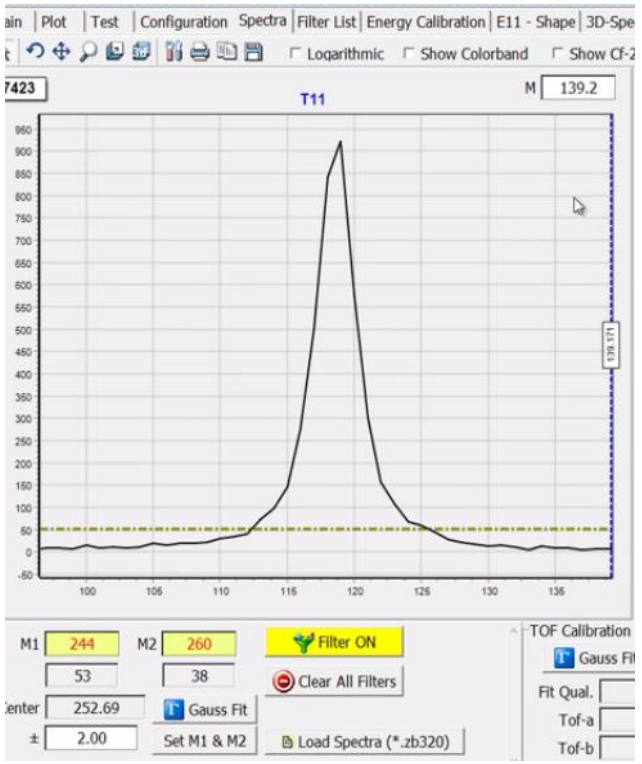


This is the energy spectrum. These are four peaks which represent alpha particles with four different **observable** energies.

DATA PROCESSING



- This is the time-of flight spectra.
- Each of the four peaks on the left represents the time of flight of one particle in the previous slide.
- The peak to your right is a filtered



RESOLUTION CALCULATION

TIME RESOLUTION

Total counts = 929 counts

$\therefore$ FWHM is at 460 counts and FWHM = 3 channels.

Maximum peak position = 118.7

$$Relative\ energy\ resolution = \frac{3}{118.7} \times 100 = 2.5\%$$

If $T_{filtered} = 8\ ns$

Time resolution = 0,44 ns = 440 ps

ENERGY RESOLUTION

Total counts = 2100

$\therefore$FWHM is at 460 counts and FWHM = 6 channels.

Maximum peak position = 253

$$Relative\ energy\ resolution = \frac{6}{253} \times 100 = 2.4\%$$

If $E_{max} = 7.687$ MeV

Energy resolution = 0.18 MeV or 180 KeV

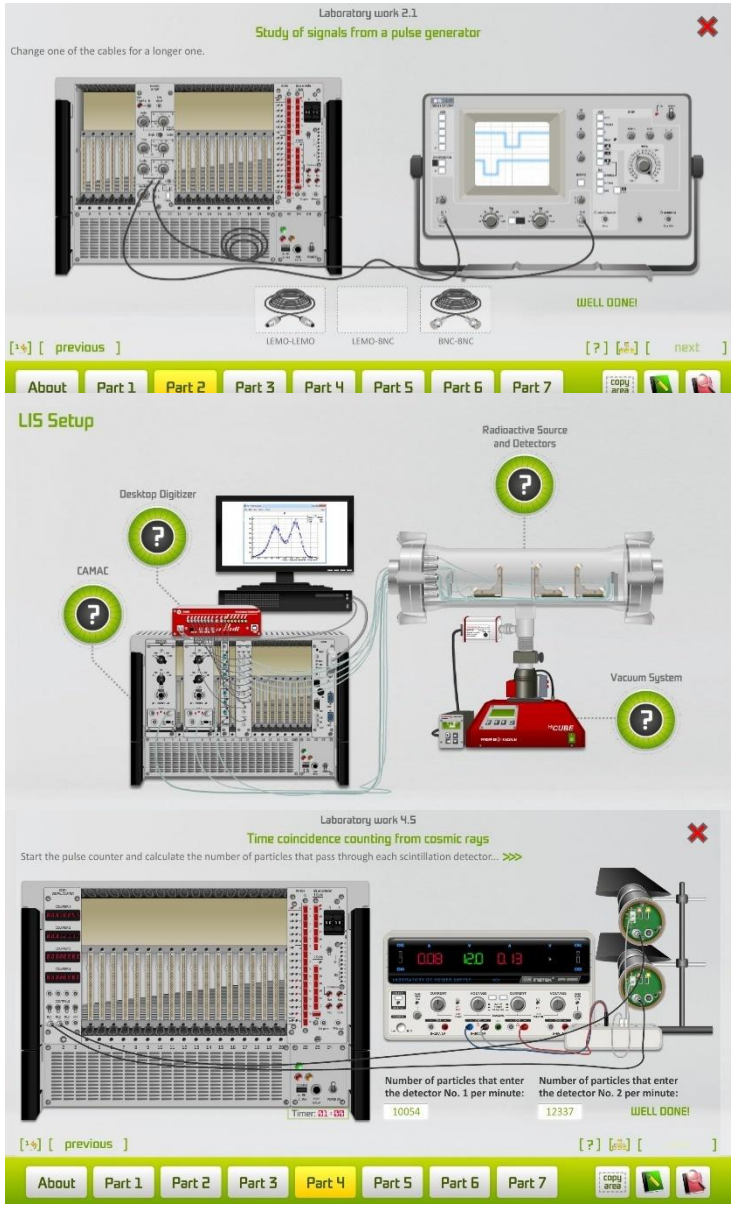
VIRTUAL LABORATORY

The main goal of the virtual laboratory is to conduct experiments (eg. Time of Flight-energy (TOF-E) spectrometry) and include the scientific data, obtained in the experiments, in a virtual laboratory for students to conduct virtual and online laboratory research using modern scientific equipment and data obtained from the existing physical facilities.

CONCLUSION

In conclusion we were able to learn how to assemble the spectrometer and use it for the our practicum and collected the data.

we also recorded videos and voice recordings for the development of the virtual laboratory.


Laboratory work 2.1
Study of signals from a pulse generator
Change one of the cables for a longer one.
WELL DONE!
LEMO-LEMO
LEMO-BNC
BNC-BNC
[previous]
[next]
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Part 1
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Part 4
Part 5
Part 6
Part 7
LIS Setup
Radioactive Source and Detectors
Desktop Digitizer
CAMAC
Vacuum System
Laboratory work 4.5
Time coincidence counting from cosmic rays
Start the pulse counter and calculate the number of particles that pass through each scintillation detector... >>>
Number of particles that enter the detector No. 1 per minute:
10054
Number of particles that enter the detector No. 2 per minute:
12337
WELL DONE!
[previous]
About
Part 1
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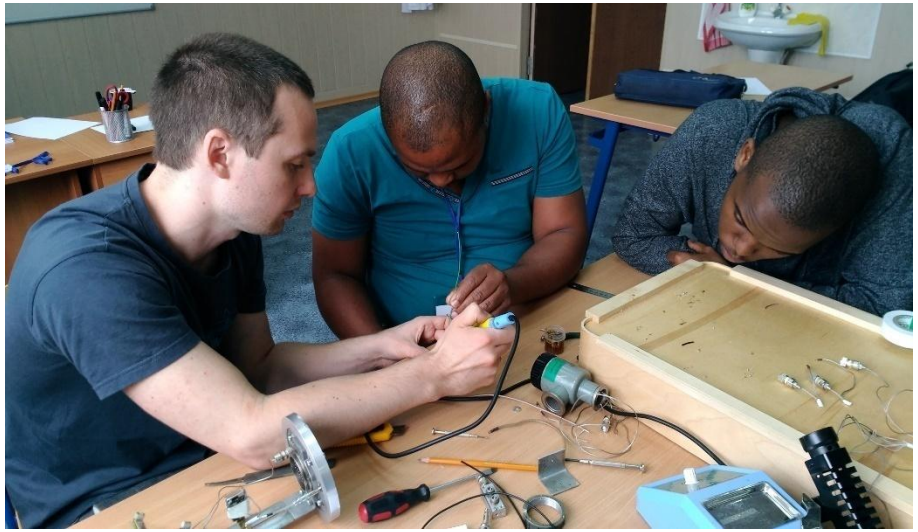
Part 3
Part 4
Part 5
Part 6
Part 7


HiCUBE

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iThemba LABS

Laboratory for Accelerator Based Sciences

Thank you! (Спасибо!)

THANK YOU
FOR
YOUR
ATTENTION
ANY QUESTIONS?