Open science and outreach for astroparticle physics

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Motivation

In the application for this year in the frame of the project German-Russian Astroparticle Data Life Cycle Initiative it was announced to fill the scientific and educational portal **astroparticle.online** with new materials, including:

- materials related to astrophysics;
- course on the processing and analysis

of astrophysical data.

New regular course of ISU Physics faculty for bachelor and master students

"Introduction in experimental astroparticle physics"

- Lectures
- Seminars
- Simulation course
- Experimental labs

Two world-known actively developing astroparticle experiments in Baikal region, which in turn require the involvement of new members, including our students:

- TAIGA observatory
- Neutrino telescope Baikal-GVD

Goal: to create working group at ISU

Seminars (examples of tasks)

(will include necessary description and examples of solutions):

- What is the effective area that the installation should have for detecting cosmic rays, one can measure the intensity of cosmic rays with energies more than 10^19 eV with a static accuracy of 10% (using it for a year of work).
- Determine the threshold energy of the proton for the process of photoproduction of an electron-positron pair in the interaction of a proton with relic radiation:

$$p + \gamma \rightarrow p + e^- + e^+$$

- Based on the power form of the cosmic rays energy spectrum with the index $\gamma = 2.7$ and their total energy density 0.5 eV/ cm^3, calculate the intensity of cosmic rays with kinetic energies > 1 GeV. Assume that particles with energies > 1 GeV are relativistic and they make the main contribution to the total energy density of cosmic rays.
- How does the nuclear charge of a substance affect the absolute values of cross sections and the relative contribution of individual cross sections to the total cross section for the interaction of gamma rays with a substance?

Experimental labs

Four experimental labs have been developed to familiarize students with the astrophysics detectors:

Will contain:

- Methodic manual with a description of the instrument, goals and objectives;
- Video description;
- Sample experimental data

Laboratory telescope for studying the secondary component of cosmic rays

- The framework of the laboratory telescope (100´100´140 cm^3)
- 3 scintillation counters inside PVC light tubes

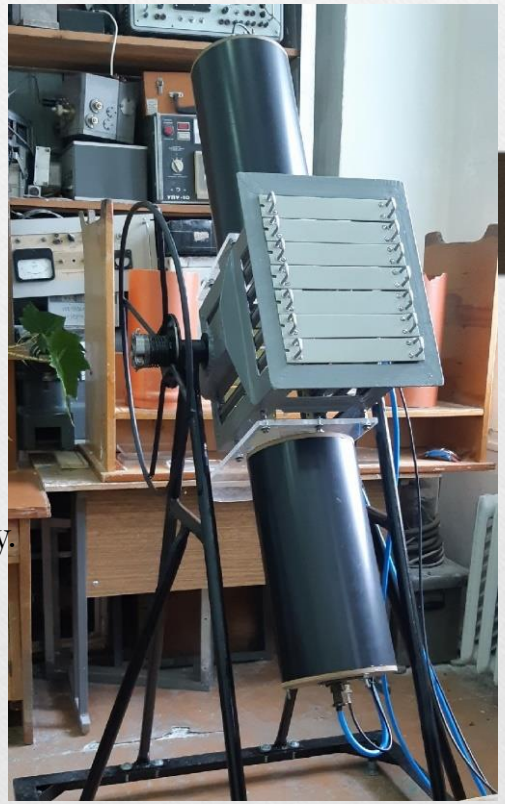
Each scintillation counter consists of

* scintillator (cylinder (R = 10 cm, H = 5 cm) from polystyrene with the addition of 2% p-terphenyl and 0.02% POPOP);
* FEU-49B photo multiplier;
* voltage divider;
* PMT power source (adjustable from 0 to 3000V)

- A set of lead filters (7 filters of the size of one 20´20´2 cm3)
- LED pulsed light source
- Two ATN-2335 power supplies and one HY1503D power supply.
- Coaxial cables, BNC connectors

Optional equipment

- NI ELVIS II Base Station +
- Lenovo B590 laptop



Laboratory work No. 1:

The intensity of the flux of the secondary component of cosmic rays at the observation level.

Objective: To determine the intensity of the flux of the lepton component of cosmic rays at the observation level.

Tasks of work:

- Get acquainted with some elements of the NIELVISII + workstation;
- Produce a set of experimental data with different thickness of the lead absorber;
- Write a program for counting the number of events while simultaneously triggering the upper and lower counters in the LabVIEW graphical programming environment and processing the experimental data with it;
- Build a graph of the dependence of the intensity of cosmic radiation on the thickness of the lead absorber;
- Estimate the intensity of the flux of the electron-photon and muon components of cosmic rays at the observation level.

Laboratory work No. 2:
The angular distribution and the lifetime of muons

Objective: To determine the intensity of the flux of the muon component of cosmic rays at different values of the zenith angle; definition of muon life.

Tasks of work:

- Get acquainted with some elements of the NIELVISII + workstation;
- Produce a set of experimental data for different values of the zenith angle;
- Write a program for counting the number of events while simultaneously triggering the upper and lower detectors in the LabVIEW graphical programming environment and using it to process the experimental data;
- Build a graph of the intensity of the flux of the muon component of cosmic rays from the zenith angle;
- Estimate the lifetime of muons.

Setup to study the fluctuations of ionization losses

The composition of the stand:

- The framework of the laboratory telescope (dimensions 100´100´140 cm3)
- Scintillation counter, consisting of:

* scintillator NE102A (plate 80´80´4 cm3).
* PHOTOHIS XP3462 photomultiplier;
* voltage divider.

- Amplification path based on operational amplifiers AD8058ARZ
- A set of coaxial cables with BNC connectors.

Optional equipment

- NI ELVIS II + base station;
- Lenovo B590 laptop.

Laboratory work No. 3:
Fluctuations of ionization losses

Objective: study of the main characteristics of the scintillation counter

Tasks of work:

- Get acquainted with some elements of the NIELVISII + workstation;
- To produce a set of experimental data at different values of high voltage;
- Write a program for constructing the amplitude distribution of the pulses of a scintillation counter in the LabVIEW graphical programming environment and process the experimental data with it;
- Compare the experimental distribution with the theoretical Gaussian distribution;
- Estimate the intensity of the flux of the secondary component of cosmic rays at the observation level.

Setup for studying the properties of photomultipliers

The composition of the stand:

- The framework of the laboratory stand
- Photomultiplier tube FEU-85
- LED pulsed light source
- PMT power supply
- A set of coaxial cables with BNC connectors.

Optional equipment

- NIELVISII + base station;
- Lenovo B590 laptop.

Laboratory work No. 4:
Investigation of PMT properties

Objective: study of the main properties of PMT

Tasks of work:

- Get acquainted with some elements of the NIELVISII + workstation;
- Obtain oscillograms of the dark and working signals of the PMT;
- Digitize the PMT signals (dark, working signals with a strong illumination and with a weak illumination) at different supply voltages;
- Write a program for constructing the amplitude distribution of PMT pulses in the LabVIEW graphical programming environment and with its help process the experimental data;
- Qualitatively assess the threshold of discrimination of PMT

The developed setups received positive feedback from TAIGA co-PI Razmik Mirzoyan.

Simulation course

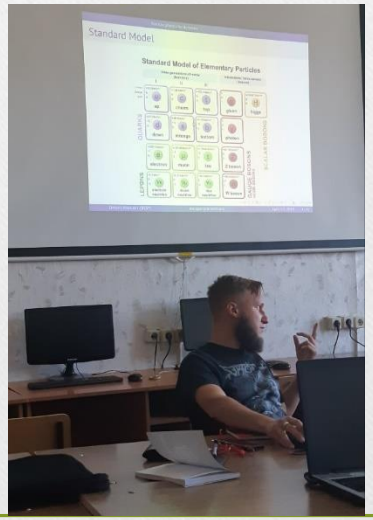
(based on pilot lectures by Dima Kostunin)

Introduction into EAS simulation:

- Theory
- CORSIKA
- COAST

Introduction into data analysis:

- ROOT
- Python
- C++



Tasks on simulation data and real experimental data

in developing…

Which platform?

HUBzero - from experience of use has bugs and errors

GRAV - a site management system (CMS) written in PHP and based on the flat file model, that is, not using any database. It is open source software.

Wordpress - content management system with open source; written in PHP; database server - MySQL

Conclusion

The new course in astrophysics has been successfully launched at the ISU, which will form the basis of the content for the scientific and educational portal **astroparticle.online**.