The microNet (μNet) project: An extended network of educational cosmic ray telescopes

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Outline

μCosmics Detector

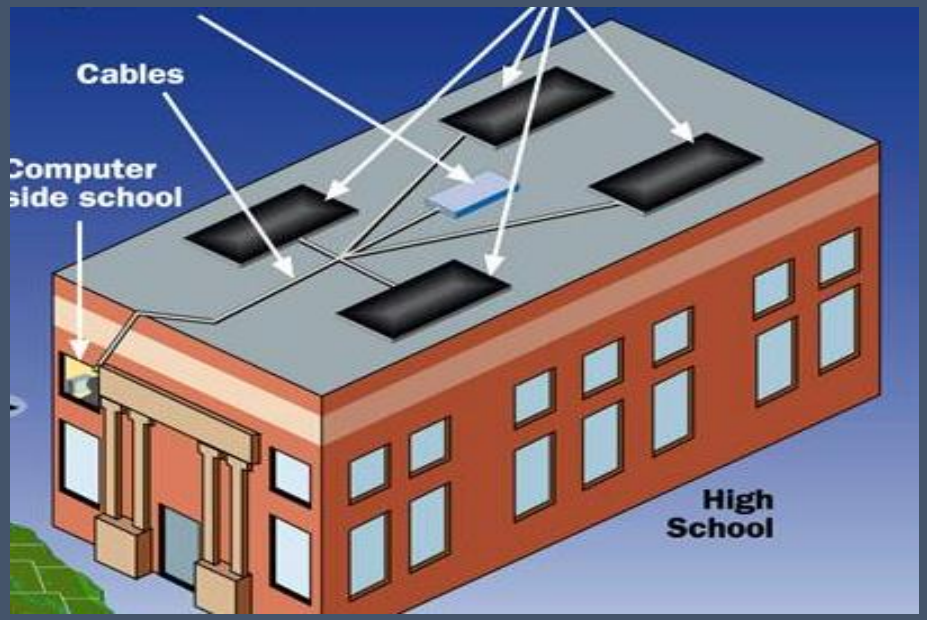
Educational Activities

The μNet Project

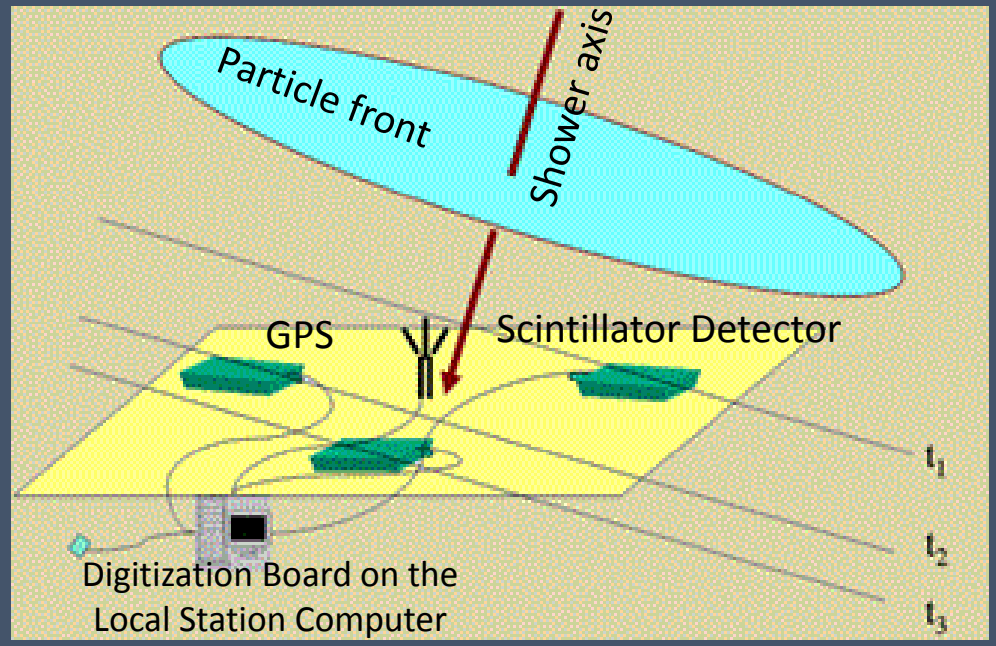
The 2021 pilot run

Educational Cosmic Ray Telescopes

A typical educational Cosmic Ray Telescope



Reconstruction of the shower direction



3-4 plastic scintillator detectors

Local Coincidence, Relative Timing and Triangulation

Shower axis reconstruction with an accuracy of a few degrees.

Astroneu

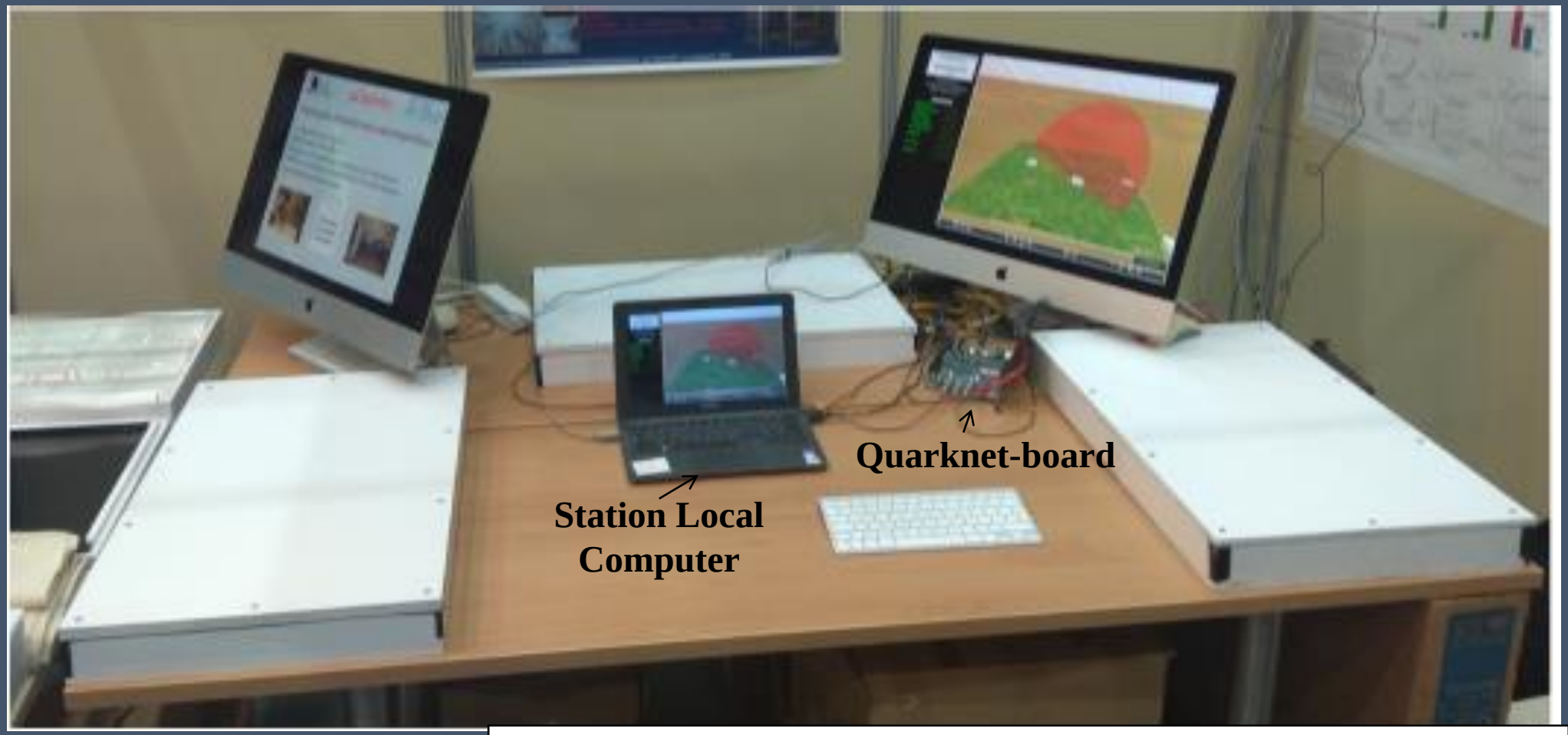
http://astroneu.eap.gr/

The Astroneu array at HOU campus

Each station consists of

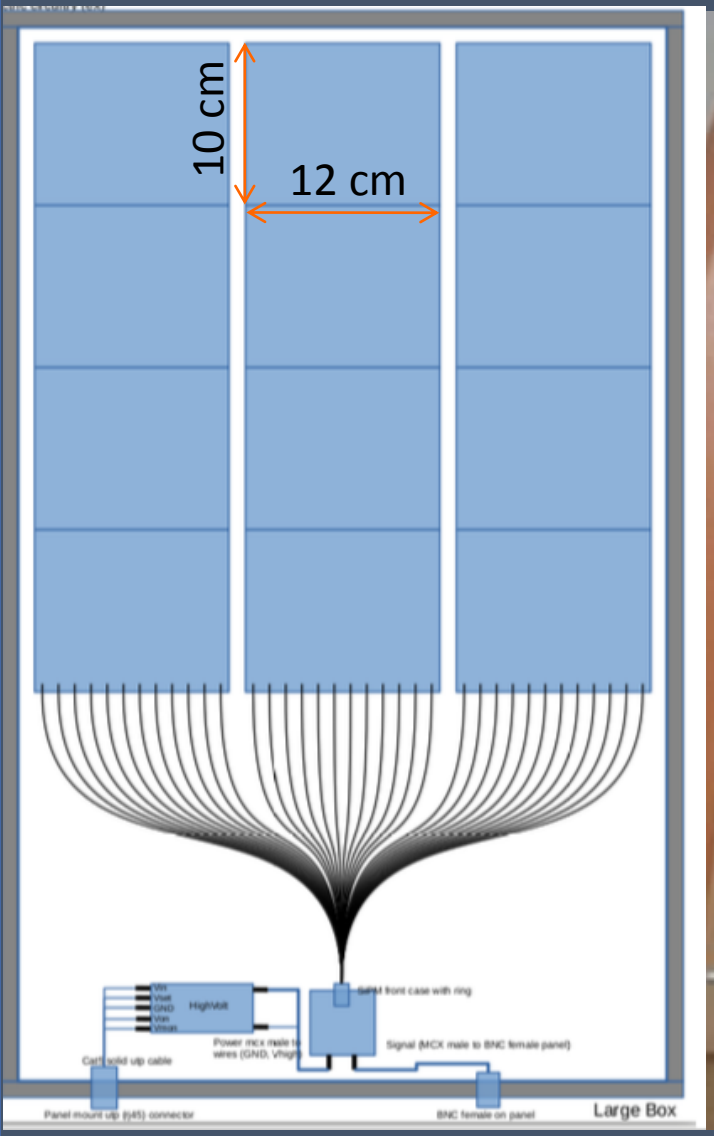
- 3 scintillator counters (~30 m spacing)
- RF antenna (autonomous station)
- DAQ and Slow Control electronics
- Power Supply, Monitoring system

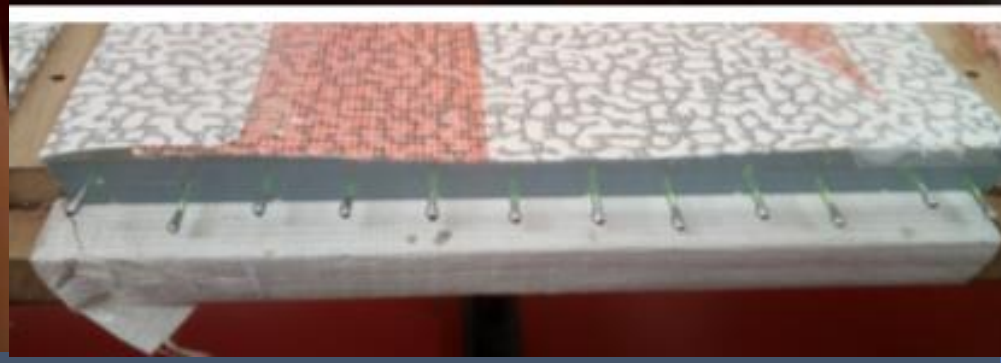
The μCosmics Detector



MDPI, Universe 2019, 5(1), https://doi.org/10.3390/universe5010023

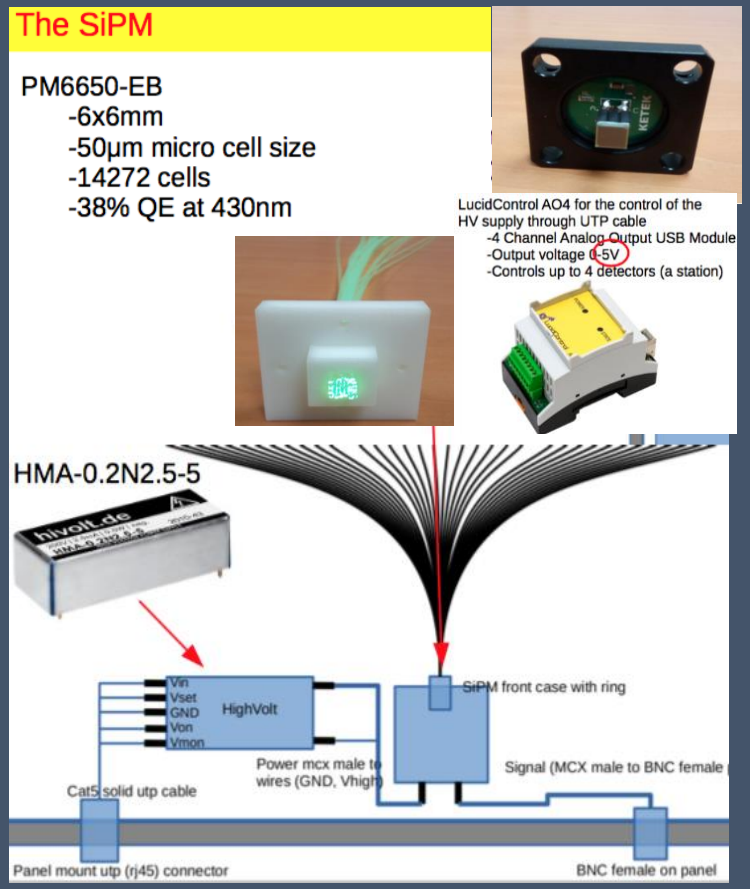
The μCosmics Detector



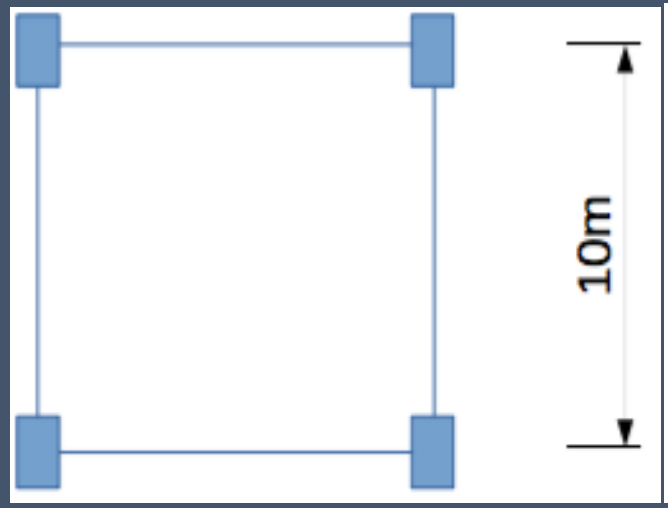


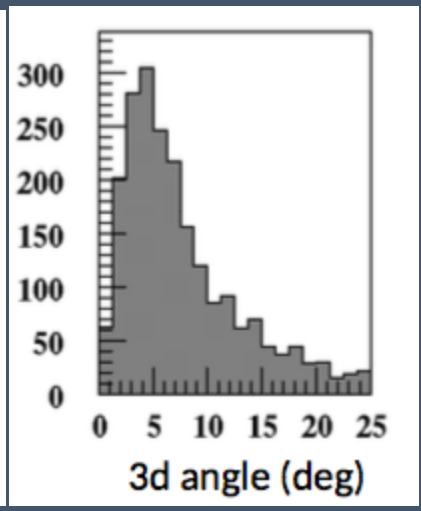
The μCosmics Detector

Integrated Detector



Performance Studies





Threshold 20 mV (1 MIP)
Timing @ 6 mV
Median 6.5 deg
236 per day, 10 per hour

The μCosmics Detector

Quarknet DAQ

Quarknet-Board

- 4 input channels with amplification.
- Time tagging is performed in one adjustable threshold.
- The time resolution for timing and ToT measurement is 1.25 ns.
- The trigger logic is based on the level of coincidence.
- It provides a trigger out signal
- It is operated through the USB port of the PC
- it is connected with an External GPS receiver.

Hantek DAQ

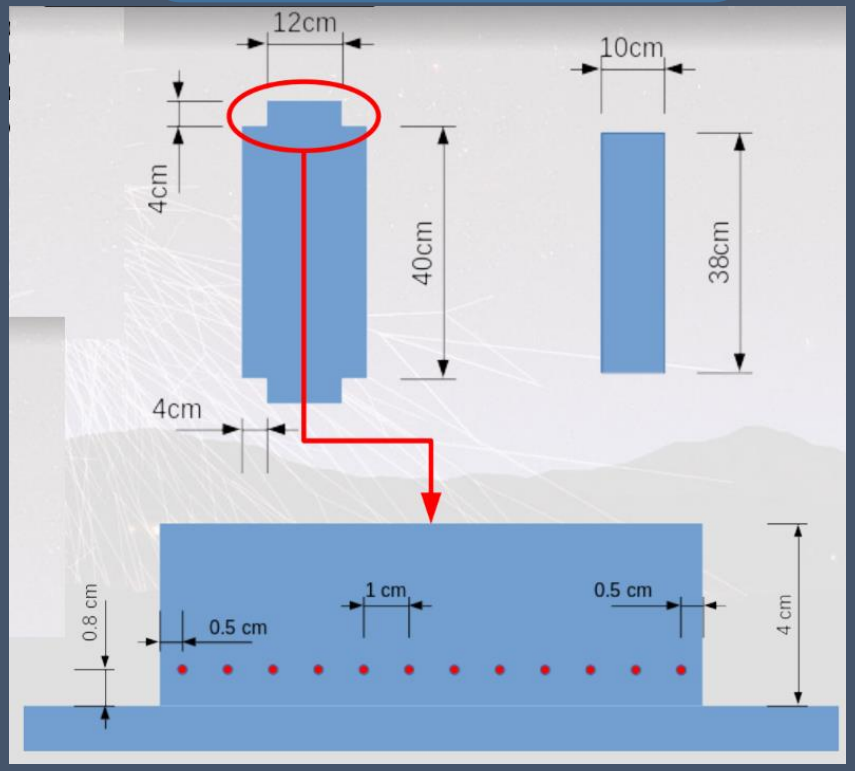
Hantek DSO3204A

- 1 Gsa/s acquisition rate
- 250 MHz Analog Bandwidth
- 4 input channels with amplification.
- It is operated through the USB port of the PC
- Full waveform digitization
- no GPS time-tagging.
- No trigger out

Educational Activities with μCosmics

Detector Assembly

Scintillator Cleaning
Tyvek Cut



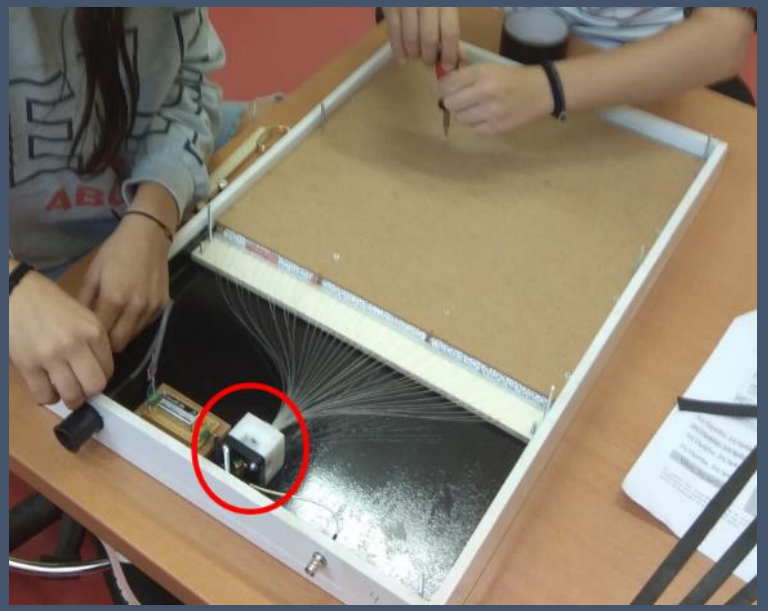
Tile Positioning
WLS fibers insertion
Tyvek positioning

2020 Phys. Educ. 55 055005, https://doi.org/10.1088/1361-6552/ab921b

Educational Activities with μCosmics

Detector Assembly

Connectors positioning
SiPM attachment



Light Proofing

Final Test
Dark Current measurement

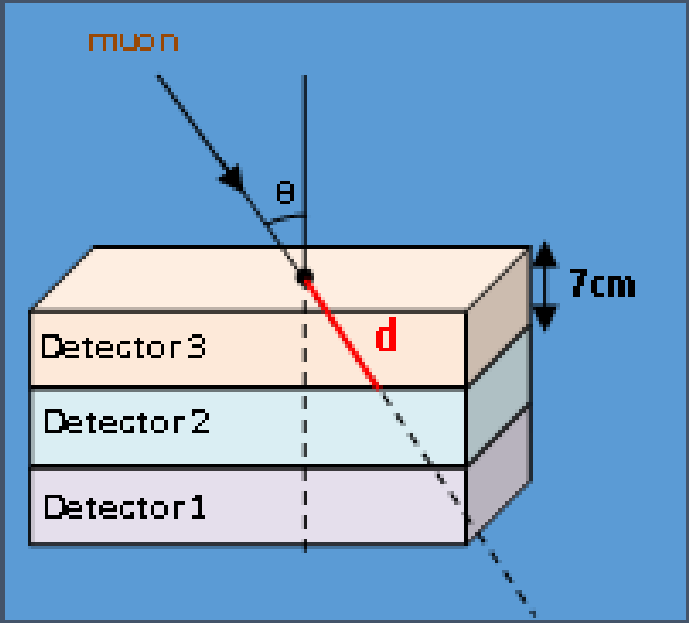
Educational Activities with μCosmics

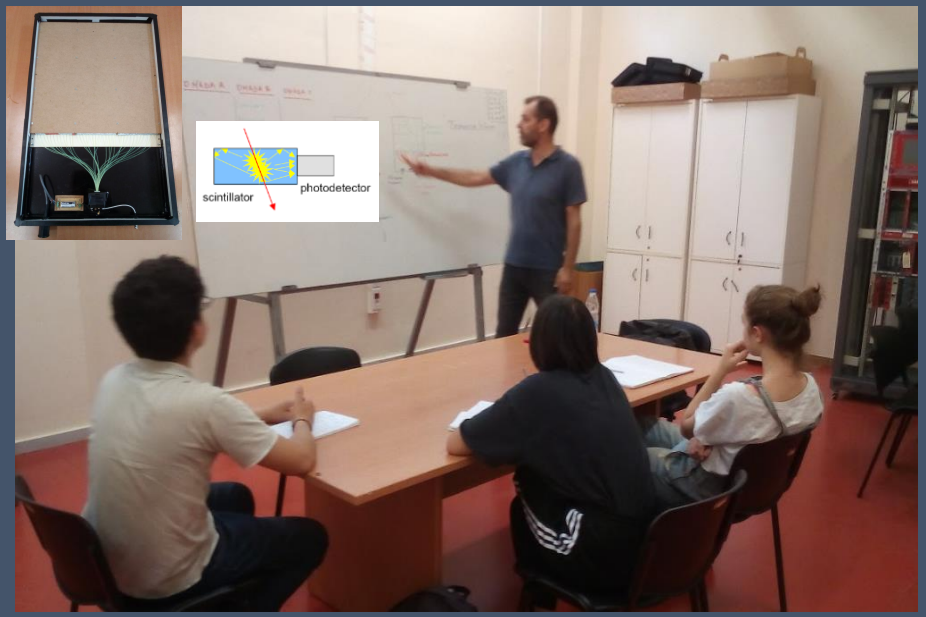
Detector Calibration

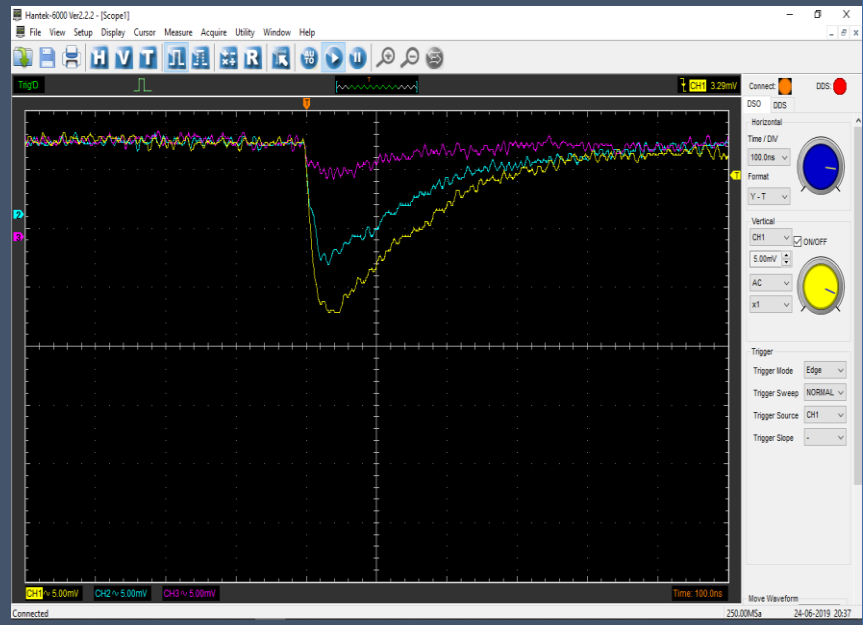
Experimental Setup

Principle of operation

Data acquisition







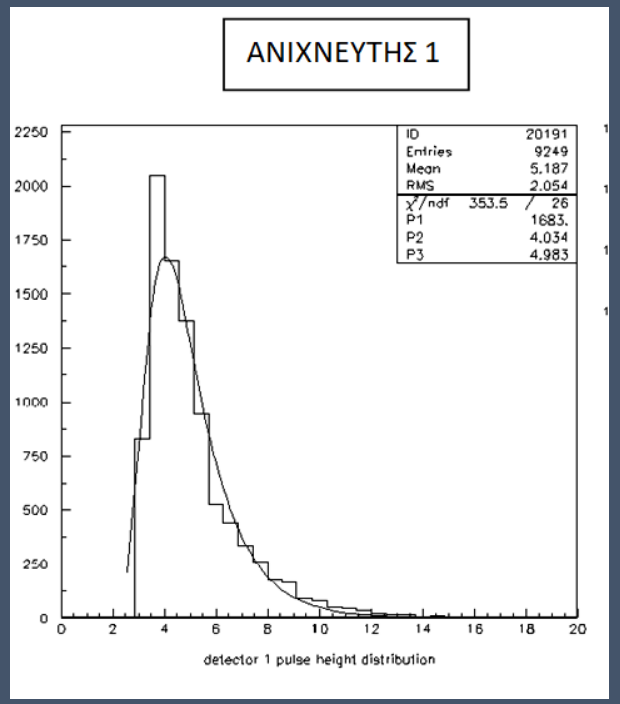
Educational Activities

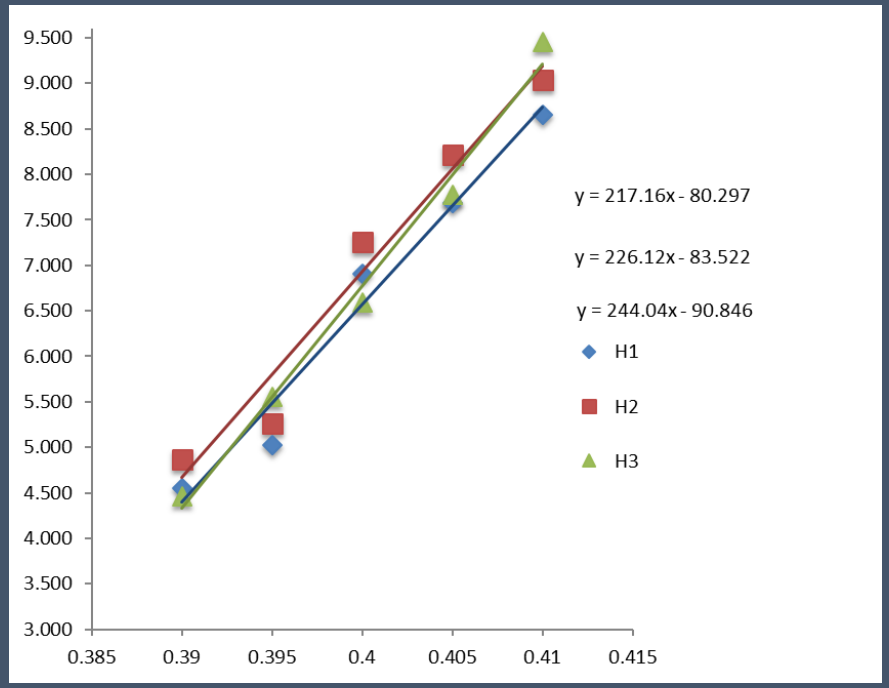
Detector Calibration

Data Analysis

Calibration Curve

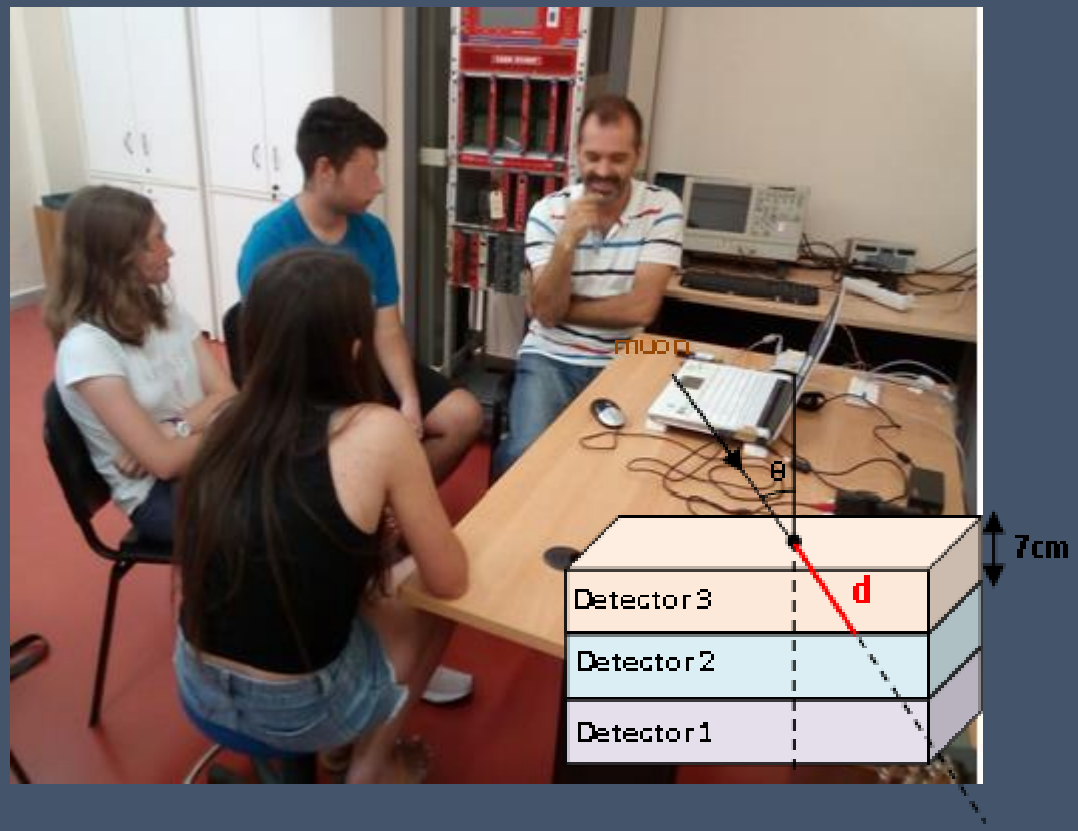
Computation

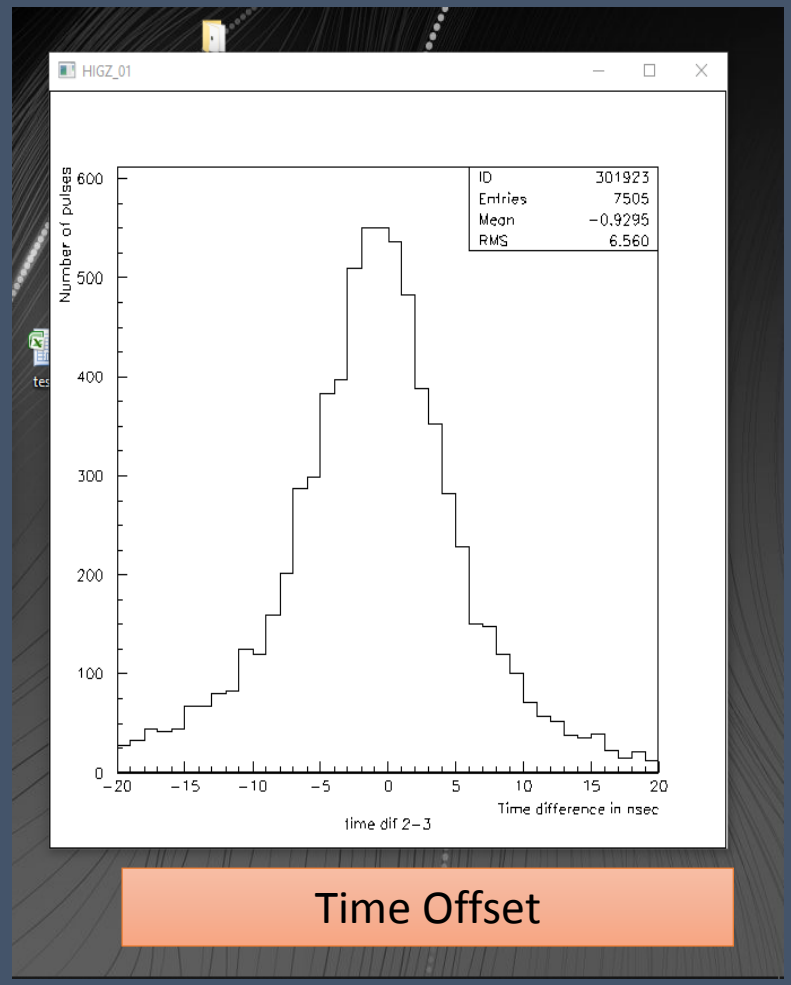




Educational Activities with μCosmics

Detector Timing Synchronization

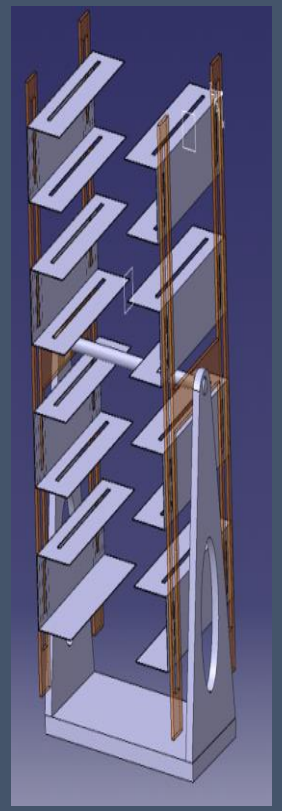


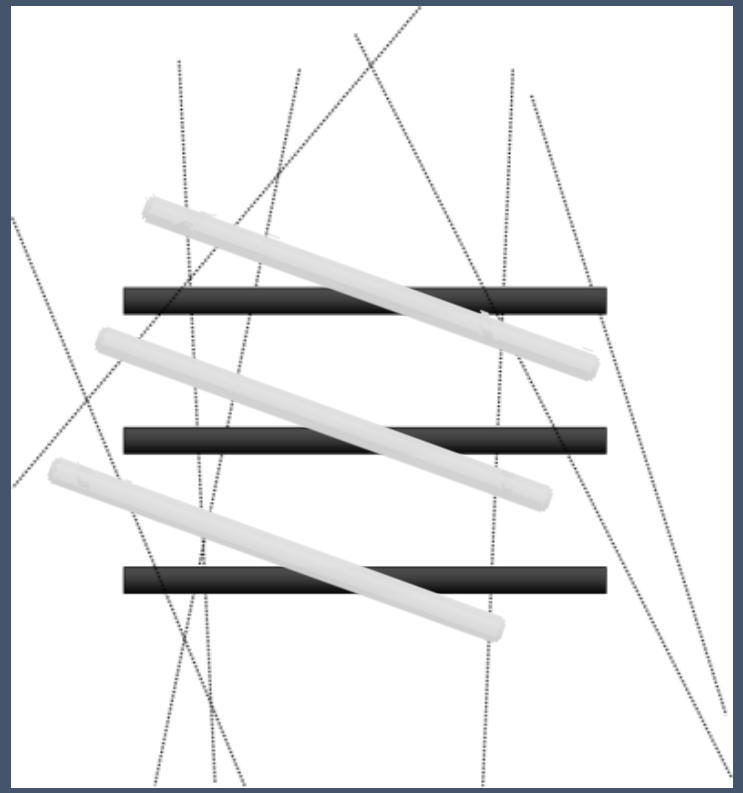


Time Offset

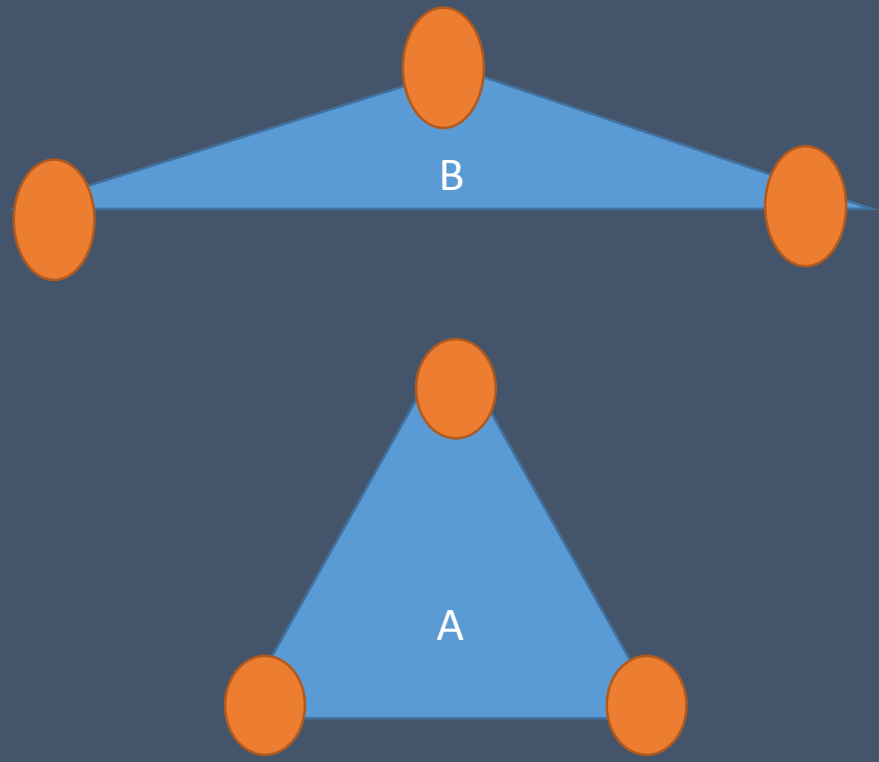
Educational Activities with μCosmics

Muon Telescopy



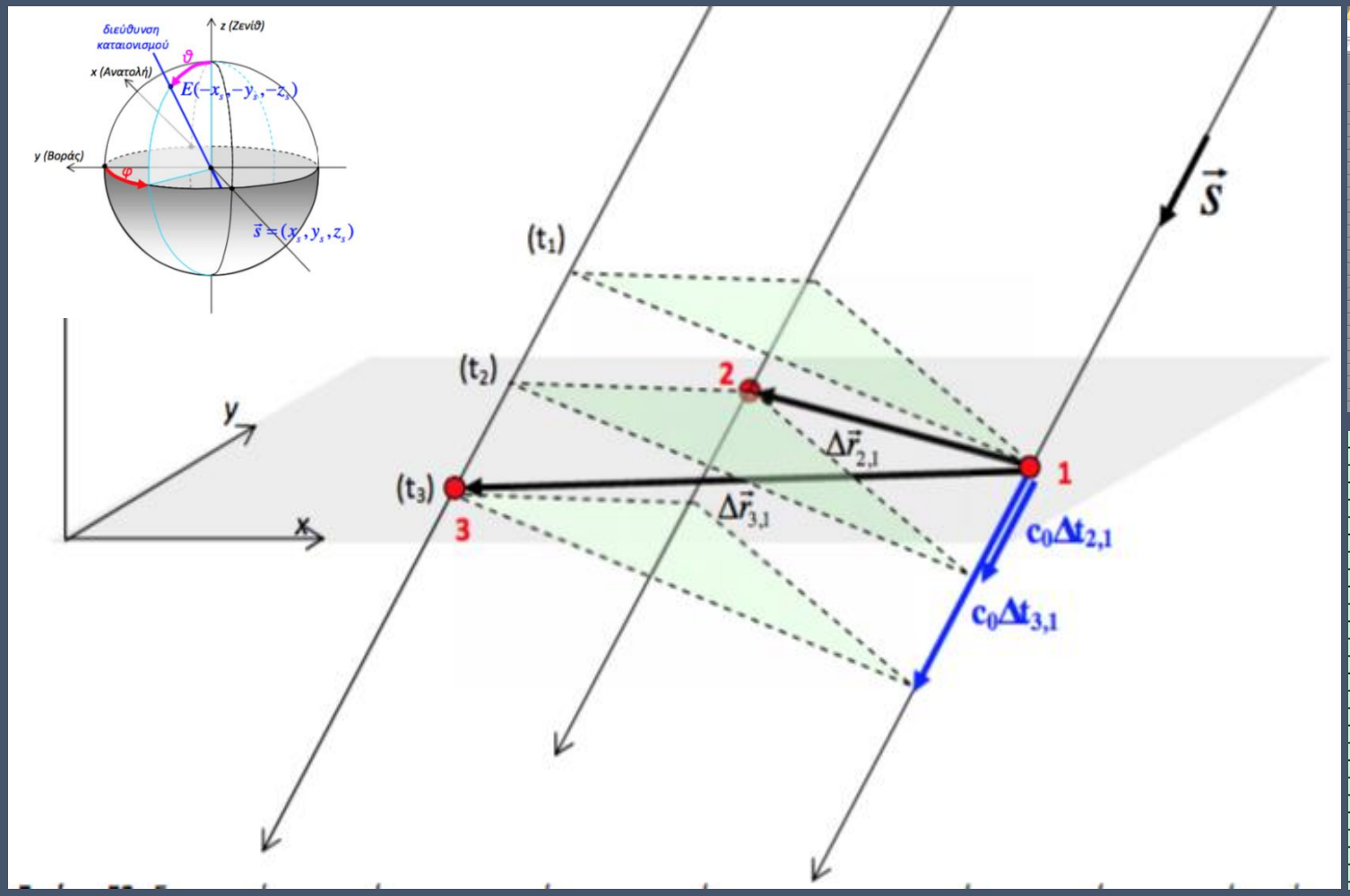


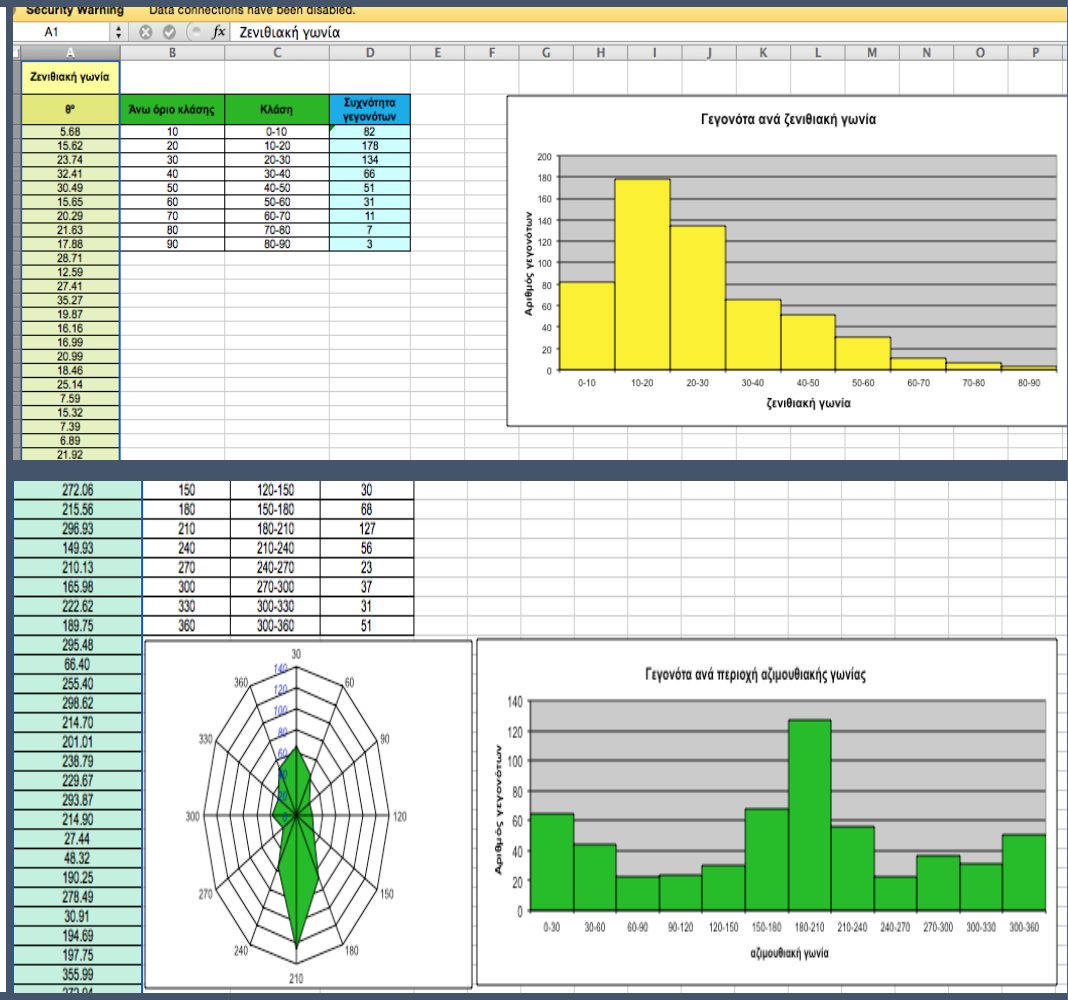
Geometry Studies



Educational Activities with μCosmics

Shower Reconstruction-Data Analysis



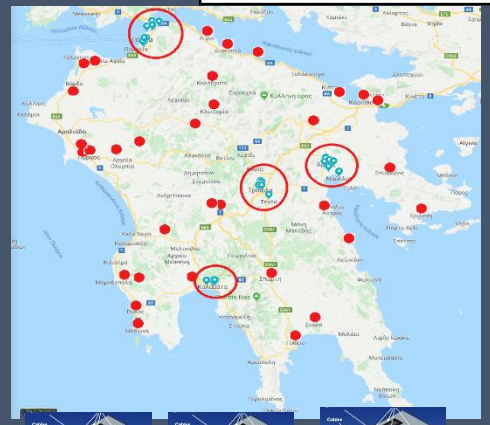


Ζενιθιακή γωνία			
θ°	Άνω όριο κλάσης	Κλάση	Συχνότητα γεγονότων
5.68	10	0-10	82
15.62	20	10-20	178
23.74	30	20-30	134
32.41	40	30-40	66
30.49	50	40-50	51
15.65	60	50-60	31
20.29	70	60-70	11
21.63	80	70-80	7
17.88	90	80-90	3
28.71			
12.59			
27.41			
35.27			
19.87			
16.16			
16.99			
20.99			
18.46			
25.14			
7.59			
15.32			
7.39			
6.89			
21.92			

272.06	150	120-150	30
215.56	180	150-180	68
296.93	210	180-210	127
149.93	240	210-240	56
210.13	270	240-270	23
165.98	300	270-300	37
222.62	330	300-330	31
189.75	360	300-360	51
295.48			
66.40			
255.40			
298.62			
214.70			
201.01			
238.79			
229.67			
293.87			
214.90			
27.44			
48.32			
190.25			
278.49			
30.91			
194.69			
197.75			
355.99			

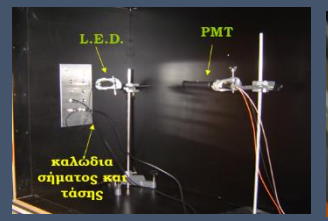
μNet

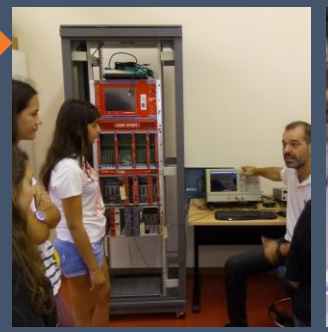
Int. Journal of Modern Physics A Vol. 35, No. 34n35, 2044022 (2020), https://doi.org/10.1142/S0217751X20440224



μCosmics detectors at high schools

μNet





Remote operated experimental setups of the HOU Physics Lab

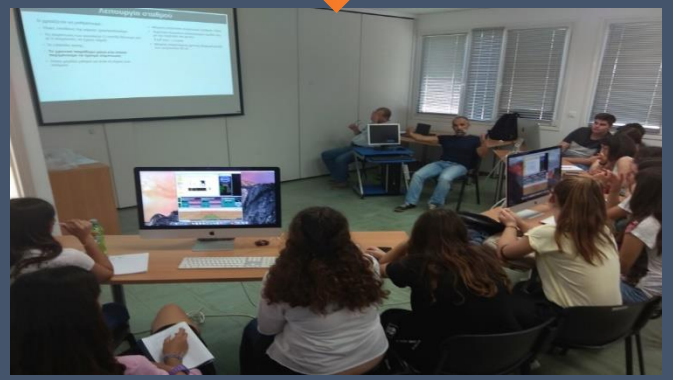
Utilization of the detection stations deployed at the HOU university campus

μNet

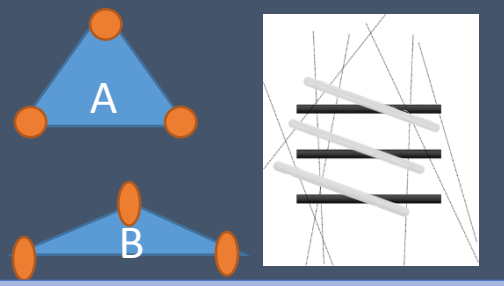
Construction of a detector unit

Calibration of the telescope

Estimation of the muon flux



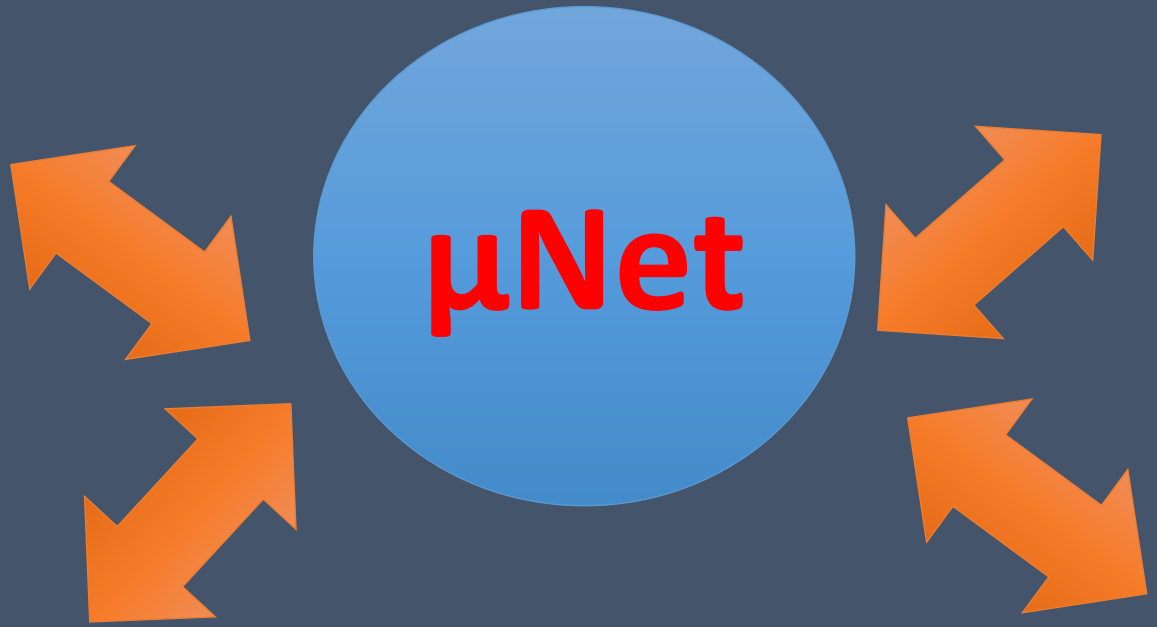
Data Acquisition and Data Analysis



Detector geometry studies

μNet

Scientific staff of the HOU Lab



High school teachers

High school students

School events & workshops
Collaboration among schools
Participation in international events

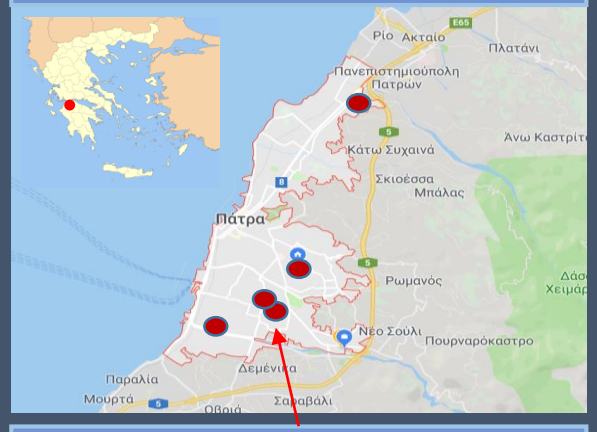
Society

The μNet Pilot Run

μNet
5 μCosmics Detectors deployed at High Schools of Patras
15 months duration
Educational Tools
Educational Activities
Training
Feedback and Evaluation

Detector Array
Construction
Calibration
Deployment and Operation at school

Deployment at 5 High Schools of Patras



2 station in adjacent schools for double station coincidence studies

Research Team (RT)
1 Faculty member
1 Post Doc Researcher
1 PhD Student

Educational Activities
Detector Unit Assembly
Response Calibration
Timing Synchronization
Muon Telescope
Operation & Monitoring
Station-Geometry Study
Data Analysis

Educational Tools
Offline & Online Software
Educational Material and MOOCS
Manuals & Questionnaires

Training
Distant Learning
Top Down approach (RT→Teachers→Students)

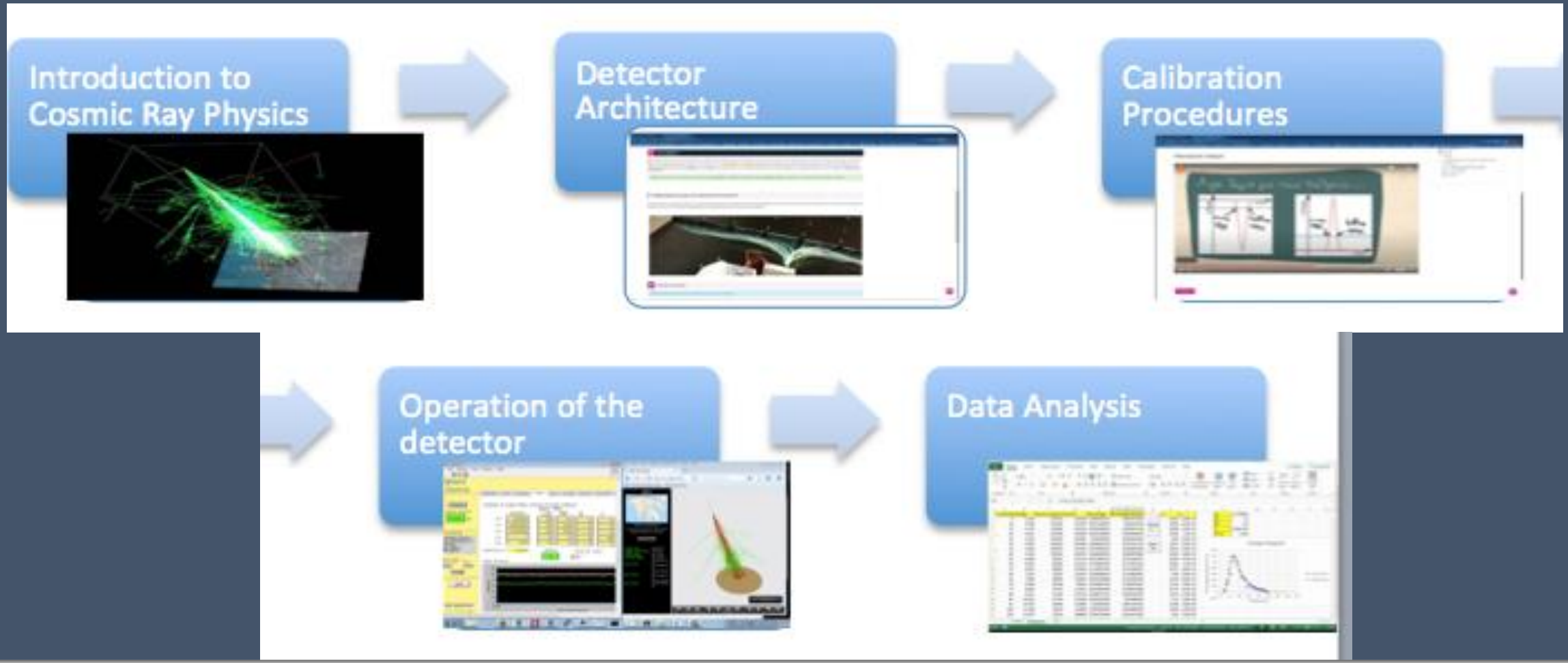
Feedback and Evaluation
Online Meetings
Discussion Forum

The μNet Pilot Run

Experimental devices located at the HOU Physics Laboratory and remotely accessed by the students

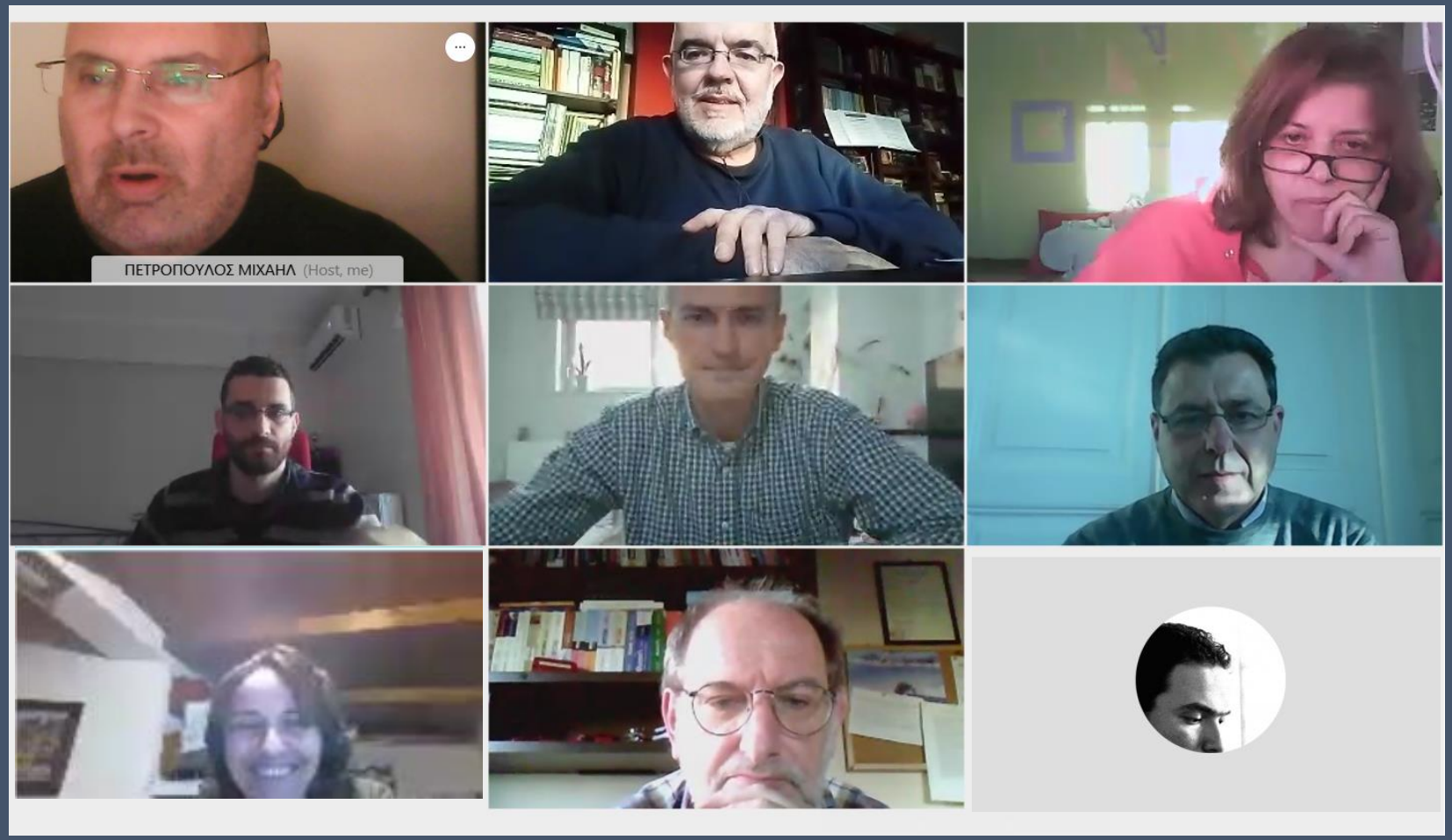
The μNet Pilot Run

The online training implemented to a dedicated moodle-platform using short videos, questionnaires and education material



The μNet Pilot Run

A snapshot of a regular weekly online meeting with the schools' teachers.



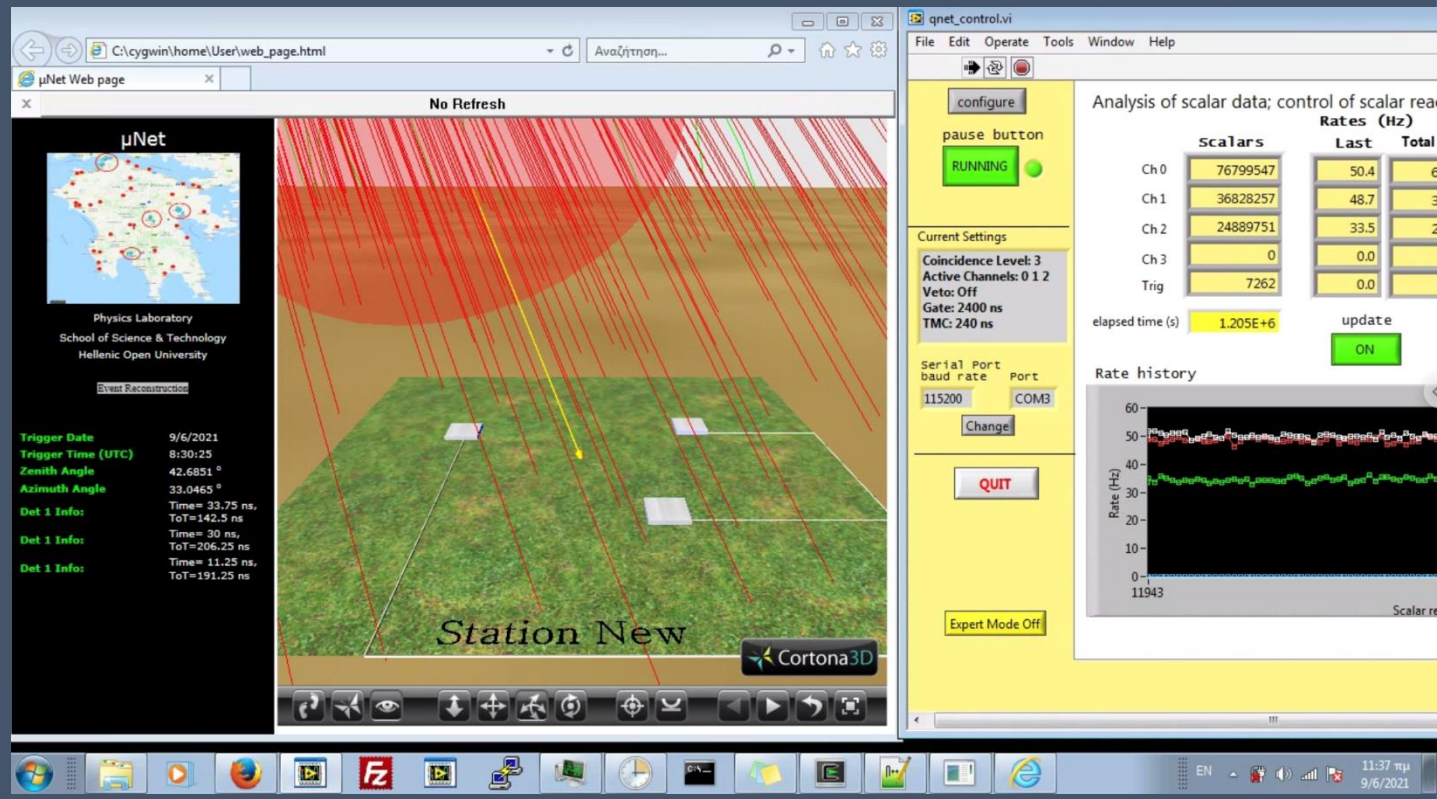
The μNet Pilot Run

Evaluation by teachers participating in the pilot program, for the distance learning μCosmics project.
(1: Not at all satisfactory, to 5: Particularly satisfactory)

Question	Answers				
	1	2	3	4	5
How interesting do you think this program is?					100%
Have you gained new knowledge from your participation?				25%	75%
The supporting material available so far, how satisfactory do you think it is?				25%	75%
How interesting do you think this program might be for students?			25%		75%
Evaluate the individual material you have studied so far.				25%	75%
How comprehensible for students can be the Physics of such a program?			25%	25%	50%
How satisfactorily do you think students can meet the laboratory and digital requirements of the program?			25%	25%	50%
Do you think that distance education can work in such research programs for students?			25%		75%

The μNet Pilot Run

High school students involvement during the pandemic



Summary

The 1st array of educational air shower detectors in Greece is under construction (μNet)

A complete set of educational activities and educational material has been developed

In situ and remote operation procedures are established

The pilot run with 5 participating schools is on the way

The μNet will be fully operational by 2023 involving more than 50 schools and 1000 students per year

Thank you !!!