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.
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

The $\mu$Cosmics Detector
The μCosmics Detector

Integrated Detector

Performance Studies

The SiPM

PM6650-EB
- 6x6mm
- 50μm micro cell size
- 14272 cells
- 38% QE at 430nm

HMA-0.2N2.5-5

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

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The μCosmics Detector

**Quarknet DAQ**

- 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 connected with an External GPS receiver.

**Hantek DAQ**

- 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

Educational Activities with μCosmics

Detector Assembly

- Connectors positioning
  - SiPM attachment
- Light Proofing
- Final Test
  - Dark Current measurement
Educational Activities

Detector Calibration

Data Analysis

Calibration Curve

Computation
Educational Activities with μCosmics

Detector Timing Synchronization

**Time Offset**
Educational Activities with $\mu$Cosmics

Muon Telescopy

Geometry Studies
Educational Activities with µCosmics

Shower Reconstruction - Data Analysis
μNet

μCosmics detectors at high schools

Remote operated experimental setups of the HOU Physics Lab

Utilization of the detection stations deployed at the HOU university campus
Construction of a detector unit

Calibration of the telescope

Estimation of the muon flux

Detector geometry studies

Data Acquisition and Data Analysis

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μNet

- Scientific staff of the HOU Lab
- High school teachers
- High school students
- Society

School events & workshops
Collaboration among schools
Participation in international events
The $\mu$Net Pilot Run

### μNet

- 5 $\mu$Cosmics Detectors deployed at High Schools of Patras
- 15 months duration
- Educational Tools
- Educational Activities
- Training
- Feedback and Evaluation

#### Deployment at 5 High Schools of Patras

- Detector Array
  - Construction
  - Calibration
  - Deployment and Operation at school

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

- Training
  - Distant Learning
  - Top Down approach (RT $\rightarrow$ Teachers $\rightarrow$ Students)

- Feedback and Evaluation
  - Online Meetings
  - Discussion Forum

### Research Team (RT)

- 1 Faculty member
- 1 Post Doc Researcher
- 1 PhD Student

### Educational Tools

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

### 2 station in adjacent schools for double station coincidence studies
The $\mu$Net Pilot Run

Experimental devices located at the HOU Physics Laboratory and remotely accessed by the students
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.
Evaluation by teachers participating in the pilot program, for the distance learning \( \mu \text{Cosmics} \) project. (1: Not at all satisfactory, to 5: Particularly satisfactory)

<table>
<thead>
<tr>
<th>Question</th>
<th>Answers</th>
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<tbody>
<tr>
<td>How interesting do you think this program is?</td>
<td>100%</td>
</tr>
<tr>
<td>Have you gained new knowledge from your participation?</td>
<td>25% 75%</td>
</tr>
<tr>
<td>The supporting material available so far, how satisfactory do you think it is?</td>
<td>25% 75%</td>
</tr>
<tr>
<td>How interesting do you think this program might be for students?</td>
<td>25% 75%</td>
</tr>
<tr>
<td>Evaluate the individual material you have studied so far.</td>
<td>25% 75%</td>
</tr>
<tr>
<td>How comprehensible for students can be the Physics of such a program?</td>
<td>25% 25% 50%</td>
</tr>
<tr>
<td>How satisfactorily do you think students can meet the laboratory and digital requirements of the program?</td>
<td>25% 25% 50%</td>
</tr>
<tr>
<td>Do you think that distance education can work in such research programs for students?</td>
<td>25% 75%</td>
</tr>
</tbody>
</table>
The $\mu$Net Pilot Run

High school students involvement during the pandemic
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 !!!