Hellenic Lyceum Cosmic Observatories Network (HELYCON) Status Report

7th International Conference on New Frontiers in Physics (ICNFP 2018)
4-12 July 2018, Kolymbari, Crete, Greece

Antonios Leisos
Physics Laboratory, School of Science and Technology, Hellenic Open University
Outline

• The HELYCON project
  • Architecture of detector units
  • Testing and calibration procedures
  • Deployment at the Lab
• Pilot operation of 3 autonomous HELYCON stations
  • The Astroneu array
  • More Testing procedures
  • Performance of a HELYCON station
• Construction of a portable Helycon station (μCosmics)
• 1st Summer School at the HOU campus
• Plans and options
The Hellenic Open University Educational Cosmic Ray Telescope

S. Tzamarias, A. Leisos, A. Tsirigotis, G. Bourlis
A HELYCON station consists of three or four plastic scintillator detectors connected to photomultiplier tubes and read out by a digitization card. The detectors are placed a few meters apart along with an antenna which uses the global positioning system to provide an absolute time reference.

Local Coincidence, Relative Timing and Triangulation

Shower axis reconstruction with an accuracy of a few degrees.
The HELYCON Detector Module (1/2)

- Scintillators: Protvino (Russia)
  - Emission spectrum: 420 nm
  - Decay time: 2 ns

- WLS fibers: Bicron (BCF-91A)
  - Light attenuation length: 330 cm

- 10 x 12 cm Scintillation tiles
  - 80 tiles ~ 0.96 m² (x2)

- 12 WLS fibers per row

- TYVEC 4650B
  - Reflective paper

- Single PMT read out
The HELYCON Detector Module (2/2)

- Fiber end point
- Photonis XP-1912
- Wrapped in Al foil
- PMT power supply
- DC-DC converter
- USB IO device
- Final box
Calibration procedures (1/2)

PMT calibration
(gain, single pe level and dark count rate)

HOU PMT Calibration Setup

- 5GS/s high sampling rate oscilloscope (Tektronix 5052B) with LAN connectivity
- Custom software for data acquisition (LabVIEW and C++)
- PMT stays in darkness without supply voltage for ~3h
- PMT powered with the typical voltage for ~1h before measurements begin

Designed as Tele-Labaratory (telephysics.eap.gr)
Webcasts & Power Point Presentations, Software packages, Step by Step instructions
Particle detectors calibration (uniformity, timing and MIP response)

- Data
  - Monte Carlo
Operation at the lab

\[ \theta = 31^\circ \pm 8^\circ \]

\[ \frac{dN}{d \cos \theta} \sim (\cos \theta)^\alpha \]
\[ \alpha = 9.4 \pm 0.6 \]

Trigger

Discriminator

(1.5 MIP)

~60 mip’s

~50 mip’s

14.2ns

5.4ns

\[ \theta = 31^\circ \pm 8^\circ \]
In 2014 3 autonomous HElycon stations were installed and are still operated at the University Campus in Patras (Greece)

Astroneu project

AUTH, DEMOKRITOS, Univ. of AEGEAN and TEI PIRAEUS, Univ. of ATHENS, HOU and Univ. of PATRAS


«THALIS - HOU - Development and Applications of Novel Instrumentation and Experimental Methods in Astroparticle Physics».

High Energy Neutrino Telescopy

Extensive Air Shower Instrumentation

EAS Telescopy: Operation & Reconstruction

Low Energy Neutrino Detection
The HOU Cosmic Ray Telescope

3 autonomous stations at the University Campus
The HELYCON Station Schematic

Each station consists of:

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

Detectors data acquisition with the Quarknet card based on the Time over Threshold technique

- 4 input channels
- 10x amplification of the input signals
- Performs time tagging of the crossings of the pulses with one adjustable threshold (set through the acquisition software)
- Time resolution 1.25ns
- Adjustable trigger criteria (majority time window)
- NIM trigger out signal
- USB connection to hosting computer
- External GPS receiver provides the absolute time of the event

CODALEMA Antenna
For showers with $E > 10^{17}$ eV

Antenna Electronics

Designed at Fermilab
Station Calibration procedures

Tests of the Quarknet cards (DAQ cards) (thresholds, timing accuracy, trigger logic)

Calibration of the whole detector array (Angular offsets, charge collection, waveform shapes etc)

DAQ card calibration

Station Calibration and testing
Parameterizations using Geant4 full simulation
• Slewling correction
• Digitization DAQ functionality
• Signal processing
• Reconstruction Studies

arXiv:1702.00945
Online Software
Performance of the HELYCON stations

<table>
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<tr>
<th>station</th>
<th>Event Rate (hr⁻¹)</th>
<th>σθ (deg)</th>
<th>σφ (deg)</th>
<th>ωmedian (deg)</th>
<th>E_{th} (TeV)</th>
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<tbody>
<tr>
<td>A</td>
<td>17.5</td>
<td>3.3</td>
<td>10.4</td>
<td>3.3</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>11.5</td>
<td>6.0</td>
<td>14.8</td>
<td>5.5</td>
<td>30</td>
</tr>
<tr>
<td>C</td>
<td>18.9</td>
<td>3.7</td>
<td>11.2</td>
<td>3.6</td>
<td>20</td>
</tr>
</tbody>
</table>
μCosmics
A portable HELYCON station

- Portable (67x42x7 cm³, light (6 kg)
- No high voltages (<40 V)
- Easy to construct

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

The power supply of the SiPM
HMA-0.2N2.5-5
-LucidControl A04 for the control of the HV supply through UTP cable
-4 Channel Analog Output USB Module
-Output voltage (5 V)
-Controls up to 4 detectors (a station)
µCosmics
A portable HELYCON station

Integrated detector

Performance – MC studies of a station with 4 detectors – Resolution and event rate – II

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

Square 10x10
DAQ

Seeking a solution

Quarknet

+ excellent performance
- Limited license (5 year)

Hantek

+ 4 ch Oscilloscope
- No GPS, no trigger logic

HOU card

Developed at the Applied Electronics Lab of Patras Univ

arXiv:1702.0106

+ excellent performance
- Not ready yet
Educational Activities

HOU Telescope

- Visits of high school students to the HOU Telescope
- Lectures for the Cosmic rays and the detection techniques
- Hands on experimentation in:
  - PMT calibration
  - Scintillator Counter uniformity and response to mip
  - DAQ performance - Signal processing
  - Operation and Monitoring of a station
  - Shower reconstruction and analysis

μCosmics detector

- μCosmics detector
  - Detector Unit construction
  - Response to mip
  - Coincidence studies
  - Geometries study
  - Operation and Monitoring of a station
  - Shower reconstruction and analysis

First data available
In collaboration with the ministry of education in Western Greece we organized a summer school for high school students (16 yr old).

15 students were selected.

Students were arranged in three groups and they were trained for a week in the Physics Laboratory of HOU.

The three groups were assigned one task each:
- 1st group: Construction of a μCosmics detector
- 2nd group: PMT calibration of a HELYCON detector module
- 3rd group: HELYCON detector module uniformity and response to mip

Each group operated a station of the HOU array.

In September they will present the results in a workshop.
1st Summer School in Astroparticle Physics For High School Students

1st day: Lectures and visits to the telescope array

2nd – 4th day:
- 1st group: construction of a μCosmics detector unit
- 2nd group: PMT characterization and testing
- 3rd group: Response of a HELYCON detector

5th day: Operation of a station by each group and shower reconstruction
1st Group: construction of a μCosmics Detector

- Cutting the fibers
- Placing the tiles
- Integration
- Cutting the tyvek
- Inserting the fibers
- Check that it’s working
- Fiber preparation
- Testing the connections
- Signing on it!
2nd Group: PMT characterization and testing

Some lessons first

Connecting electronics

Acquiring pulses

Dark box setup

Watching the signal

Making plots

Electronics setup

DAQ

Review
3rd Group: Response of a HELYCON detector

DAQ training

Measurements

Acquisition

Experimental Setup

Preparing the report
Operation of a station
Some conclusions

• Students really enjoyed it.

• Especially the 1\textsuperscript{st} group (construction of $\mu$Cosmics)

• There were complaints because they would prefer to participate in all three activities

• Didn’t like very much the 1\textsuperscript{st} day lectures

• Misconceptions about telescopes cleared

• Not enough time (3-4 hours) for station operation and monitoring

• 2 of the tutors were High School teachers. Better communication with students

• They realized the concept of teamwork and the collaboration between groups for a common objective

• They also realized that experimental failures are always expected.
Plans

• Apply for funding in Western Greece (20-30 stations at High Schools)

...if no funding

• Continue group training during the school year
• Apply more educational activities
• Remote operation of station (time sharing)
• More summer schools for students not only from Patras