HELLENIC OPEN UNIVERSITY

School of Science & Technology

Hellenic Lyceum Cosmic Observatories Network (HELYCON) Status Report

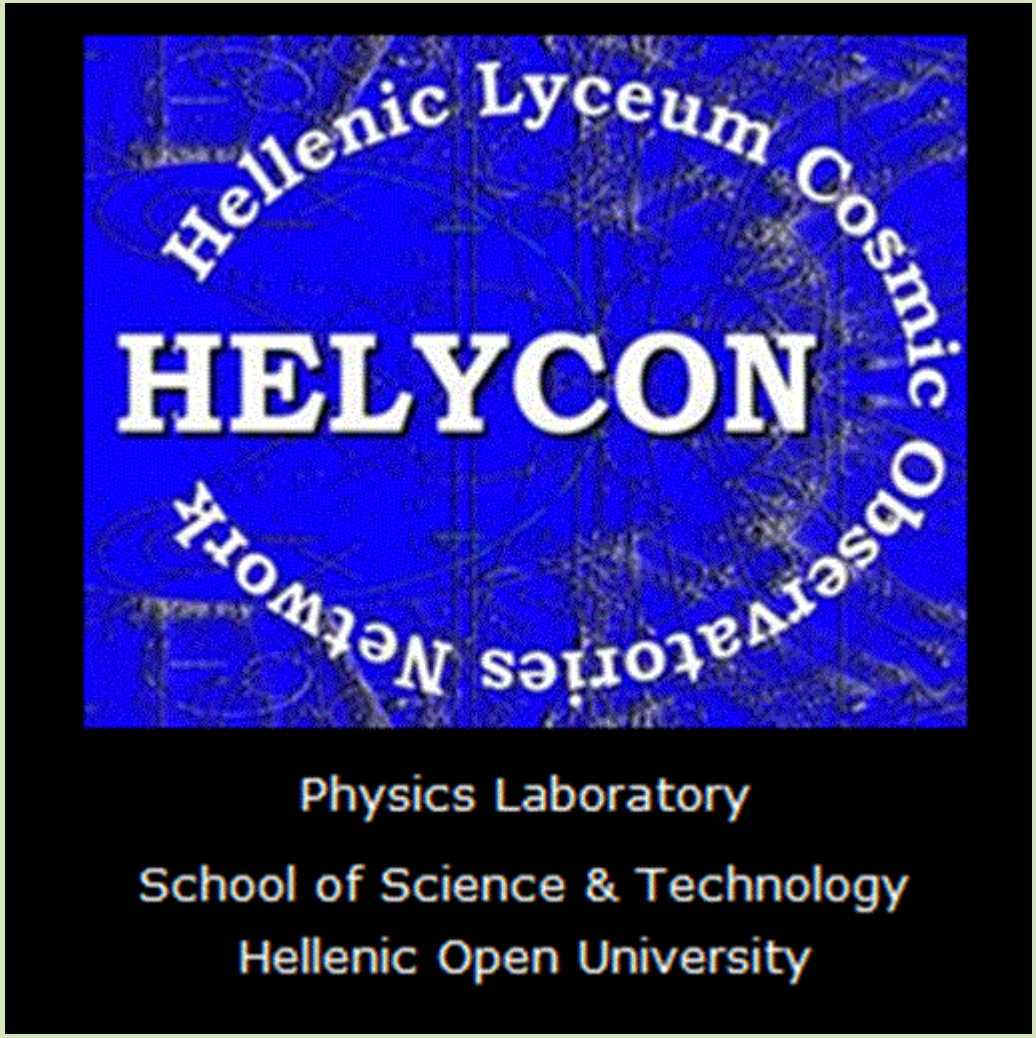
7th International Conference on New Frontiers in Physics (ICNFP 2018)
4-12 July 2018, Kolymbari, Crete, Greece

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

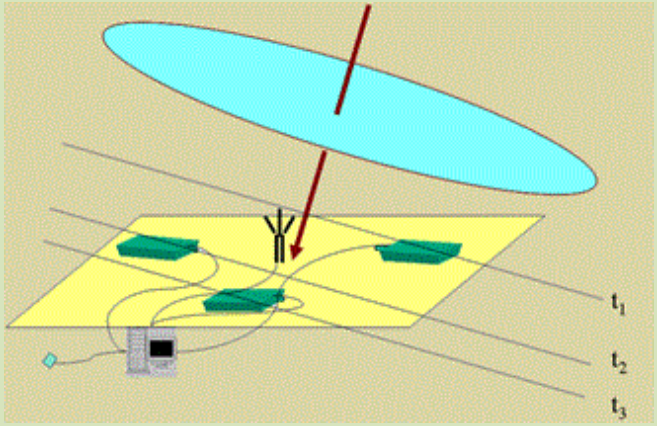
The Hellenic Open University Educational Cosmic Ray Telescope



S. Tzamarias, A. Leisos, A. Tsirigotis, G. Bourlis

The HELYCON station

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)

10 x 12 cm Scintillation tiles

80 tiles ~ 0.96 m2 (x2)

12 WLS fibers per row

WLS fibers

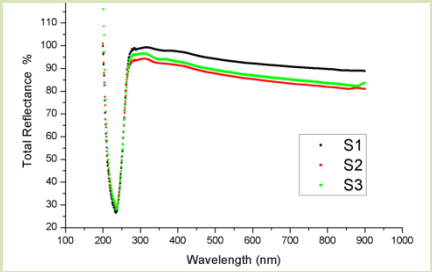
Single PMT read out

Scintillators : Protvino (Russia)

Emission spectrum:420 nm Decay time 2 ns

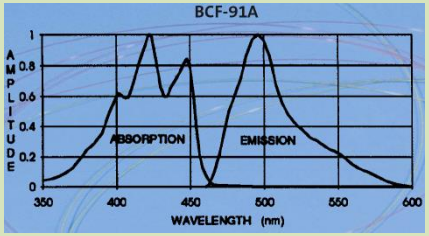
TYVEC 4650B

Reflective paper



WLS fibers: Bicron (BCF-91A)

Light attenuation length: 330cm

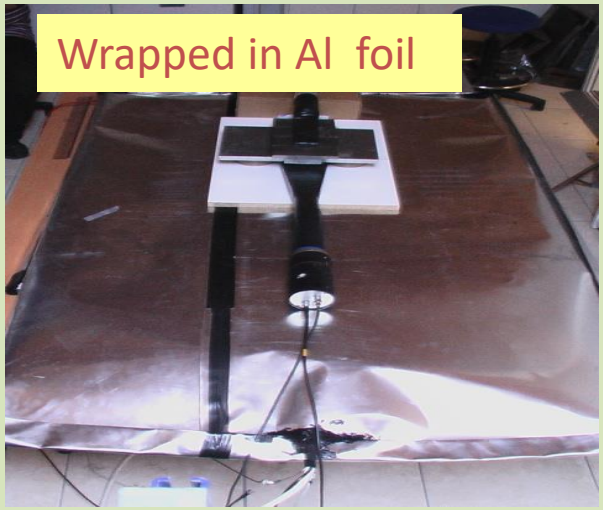


The HELYCON Detector Module (2/2)

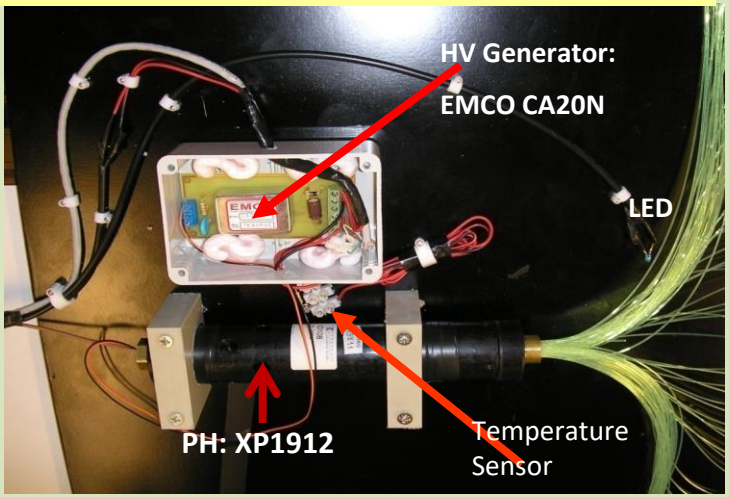
Fiber end point

Photonis XP-1912

Wrapped in Al foil



PMT power supply



DC-DC converter

USB IO device

Final box

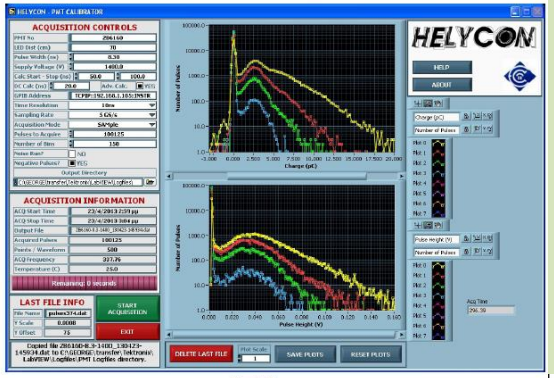
Calibration procedures (1/2)

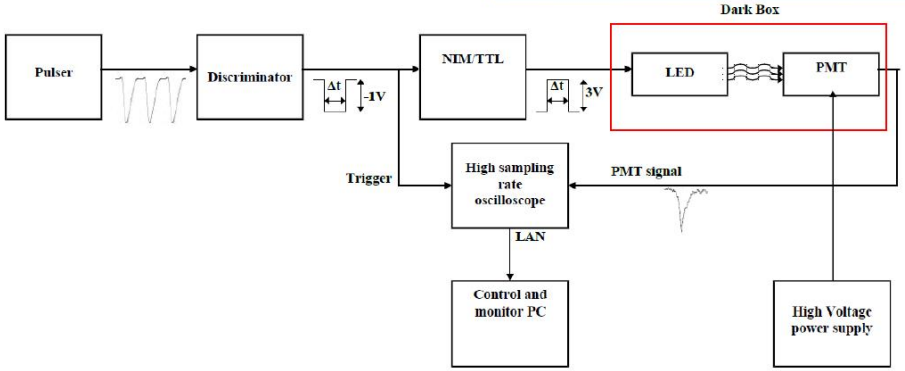
PMT calibration
(gain, single pe level and dark count rate)

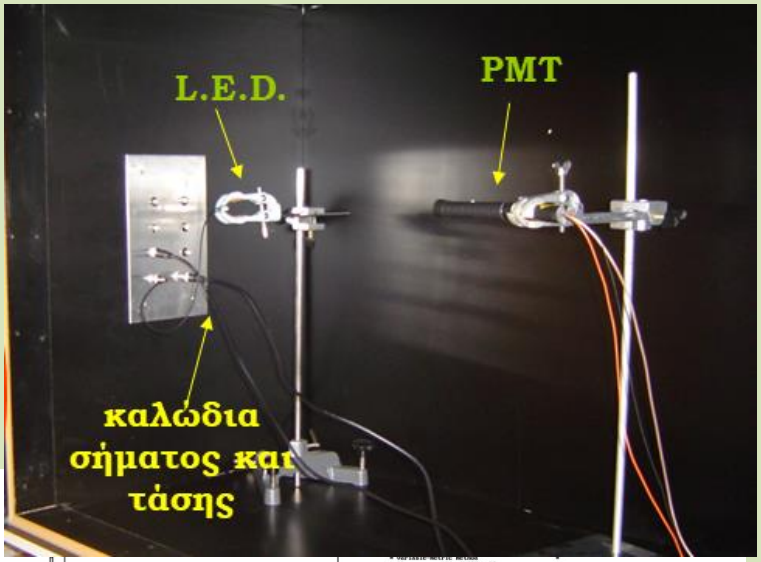
Education Activity

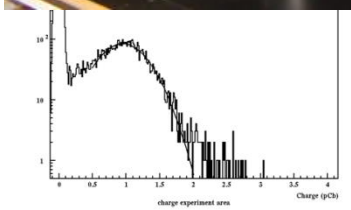
HOU PMT Calibration Setup

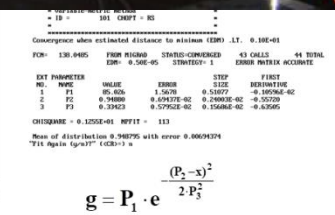
- 5GS/s high sampling rate oscilloscope (Tektronix 5052B) with LAN connectivity
- Custom software for data acquisition (LabVIEW and C++)
- PMT stays in darkness without supply voltage for ~3h
- PMT powered with the typical voltage for ~1h before measurements begin











$$g = P_1 \cdot e^{\frac{(P_2 - x)^2}{2 \cdot P_3^2}}$$

```
Enter bounds for the fit (both 0 for unbounded fit)
"Enter the lower bound" (<CR>=) 0.5
"Enter the upper bound" (<CR>=) 2
"Polya only fit or Gauss only fit or Polya+Gauss or Double Gauss or no fit(p/g/d/dg/n)?" (<CR>=) g
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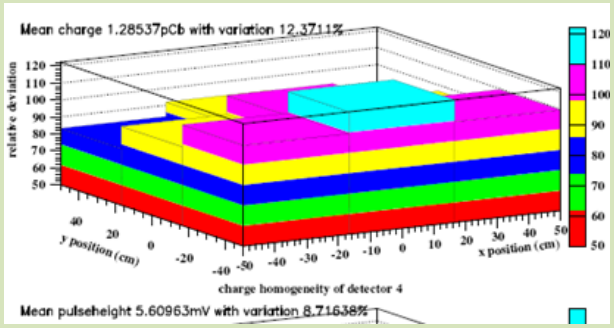
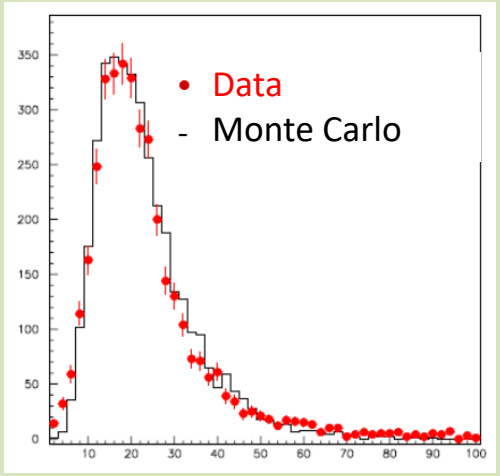
Designed as Tele-Labarotary (telephysics.eap.gr)
Webcasts & Power Point Presentations, Software packages, Step by Step instructions

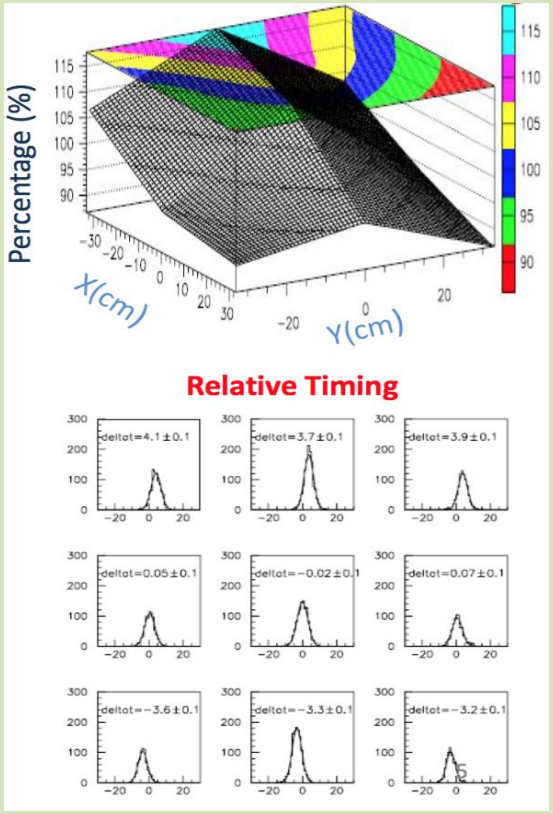
Calibration procedures (2/2)

Particle detectors calibration
(uniformity, timing and MIP response)

Education Activity



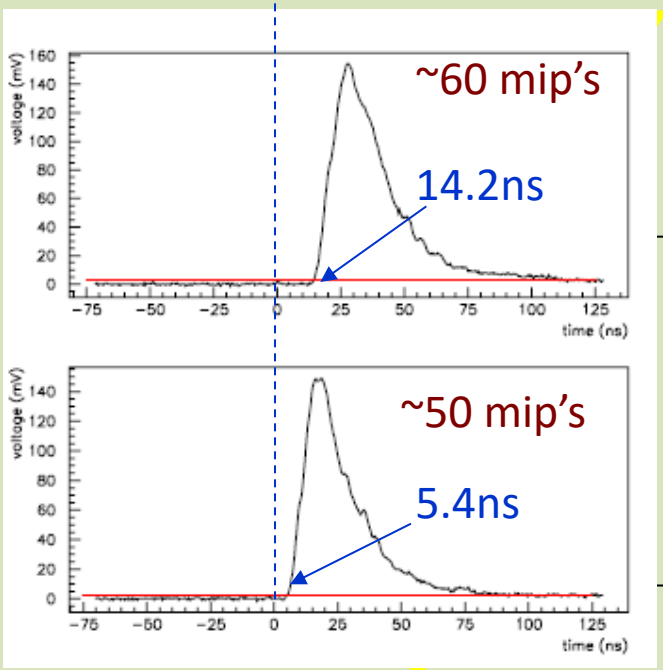


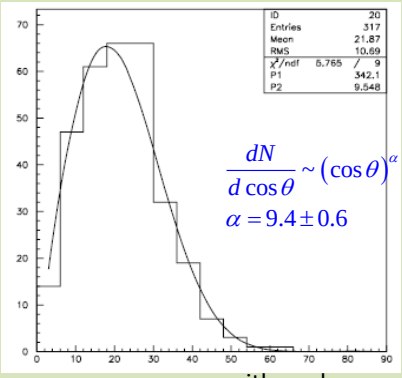


Operation at the lab

trigger
arrival time

θ=31° ± 8°

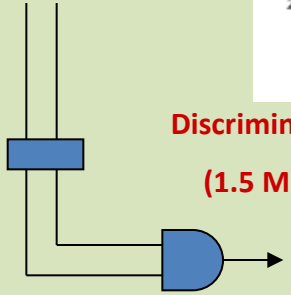




zenith angle
[degrees]

Discriminator

(1.5 MIP)



Trigger

Astroneu project

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

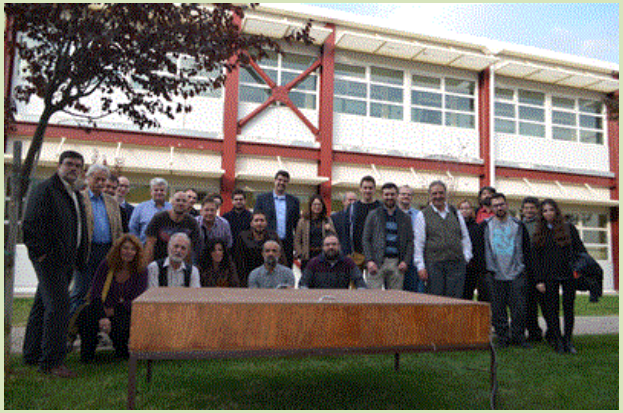
Research Team: S.Tzamarias, A.Leisos, A.Liolios, E.Savvidis, I.Katsioulas, D.Sampsonidis, Ch.Elefteriadis, Ch.Petridou, I.Maznas, G.Bourlis, A.Tsirigotis, G.Georgis, N.Giokaris, A.Manousakis-Katsikakis, E.P.Christopoulou, A.Birbas, I.Gkialas, K.Zachariadou, I.Manthos, K.Prekas, G.Fanourakis, C.Papadopoylos, D.Lenis, A.Papaoikonomou, P.Razis

External Collaborators: J.Vergados, I.Giomataris, Jean-Pierre Ernenwein, Ch.Nicolaou, Dr.J.Moussa, S.Pnevmaticos, E.Pierri, K.Siori, G.Zisimopoulos

«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

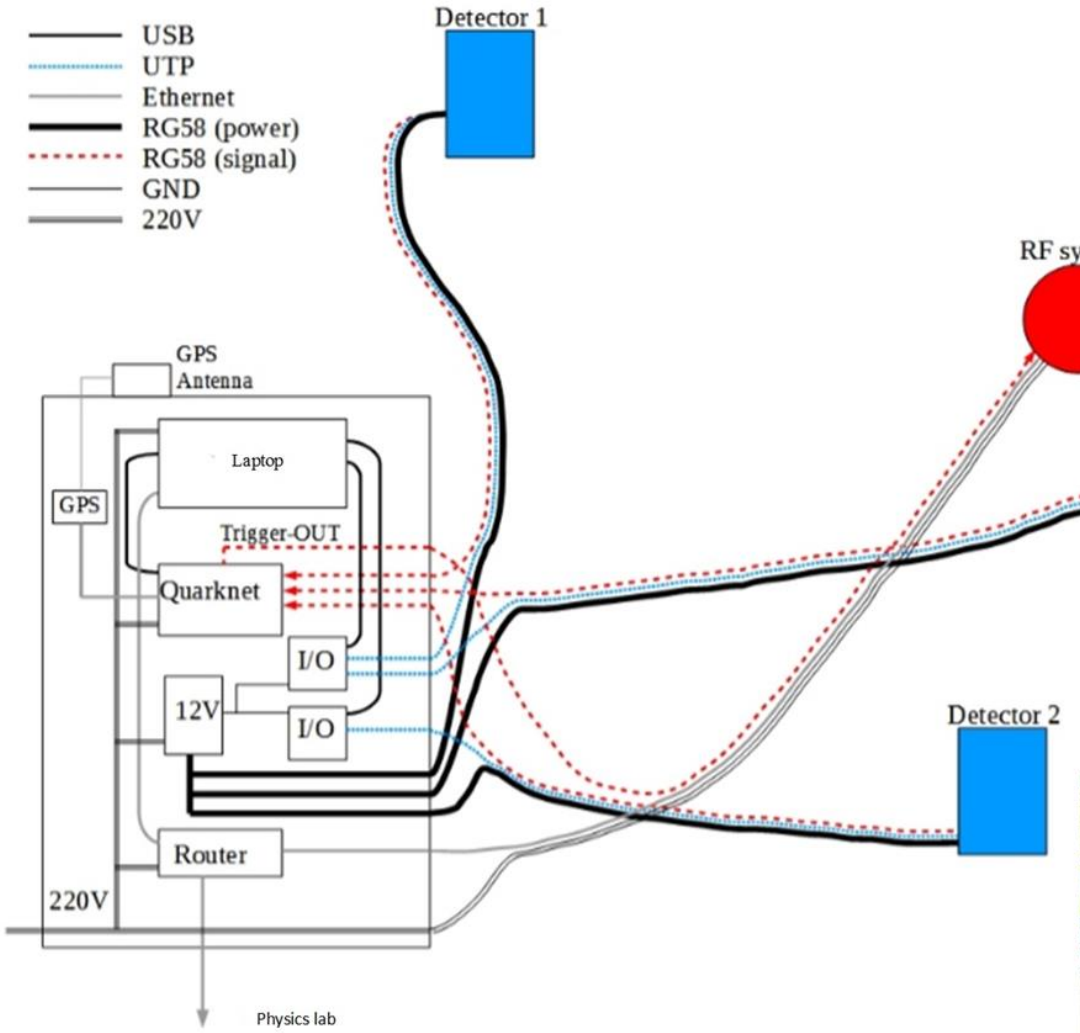
Low Energy Neutrino Detection

In 2014 3 autonomous HELYCON stations where installed and are still operated at the University Campus in Patras (Greece)

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

For showers wih E>10^{17} eV

CODALEMA Antenna

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

Designed at Fermilab

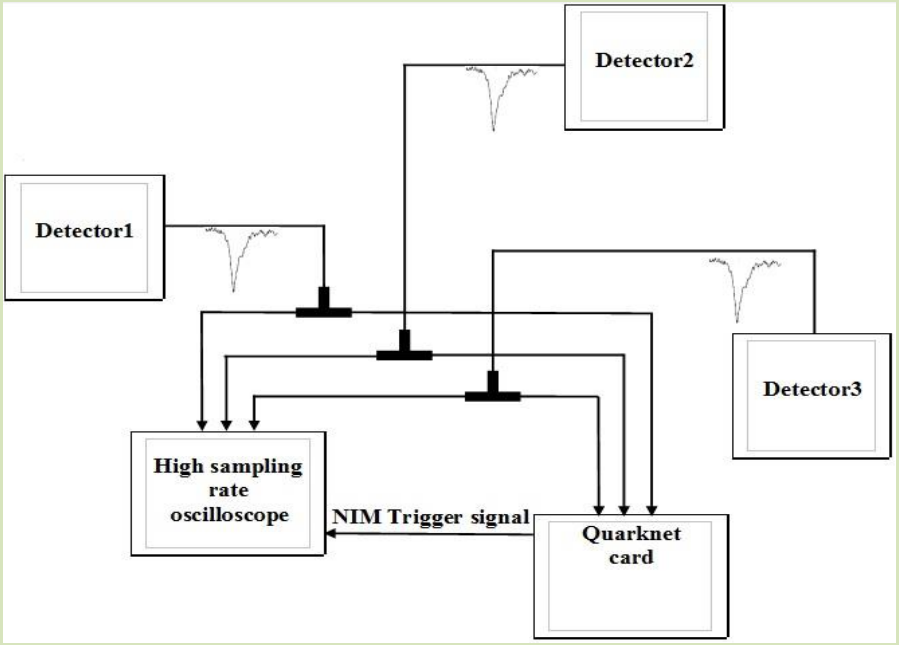
- 4 input channels
- 10x amplification of the input signals
- Performs time tagging of the crossings of the pulses with one adjustable threshold (set through the acquisition software)
- Time resolution 1.25ns
- Adjustable trigger criteria (majority, time window)
- NIM trigger out signal
- USB connection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

Antenna Electronics

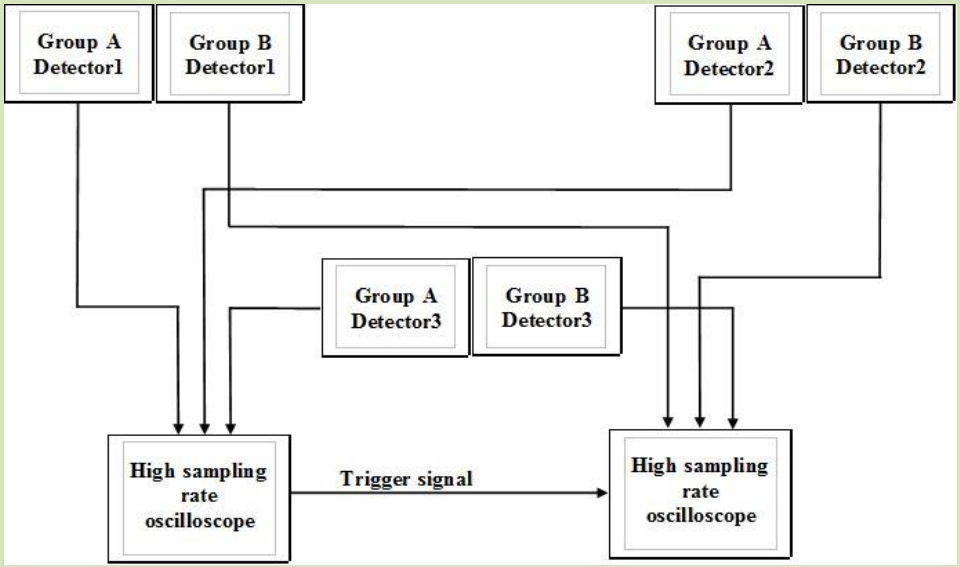
Station Calibration procedures

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

Offline Software

HOURS-EAS

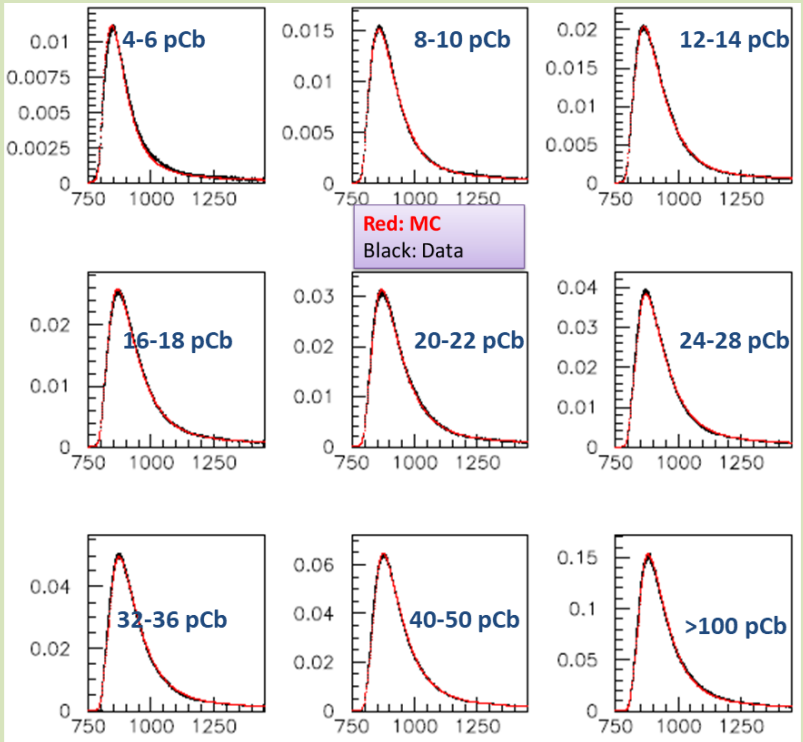
Hellenic Open University Reconstruction and Simulation of Extended Air Showers

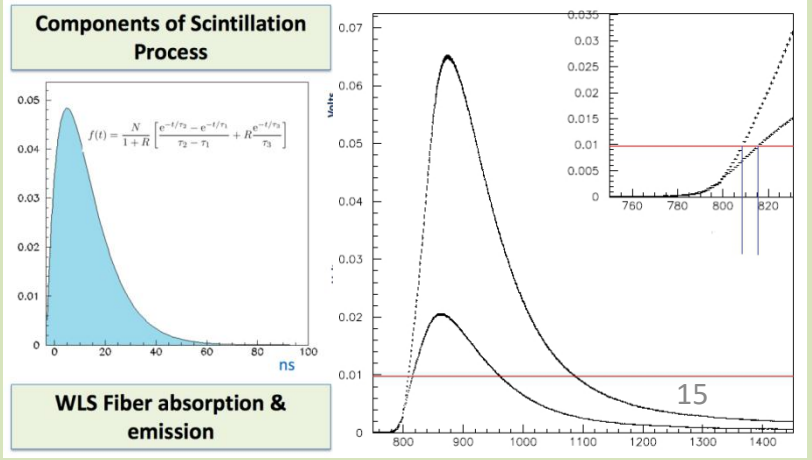
- Initialization
- CORSIKA Particle Information on the Detector Level
- Fast Simulation of Scintillation & WLS Processes
- Generation Of PMT Photoelectrons
- PMT Response Pulse
- Signal Transmission and Digitization

Detector Database
Counter Positions & Orientations, Counter characteristics, PMT characteristics, Cable Calibration, Digitization Parameters

- Initialization
- Signal Processing
- Data Quality
- Shower Reconstruction

Raw Data Creation | **Performance Plots**

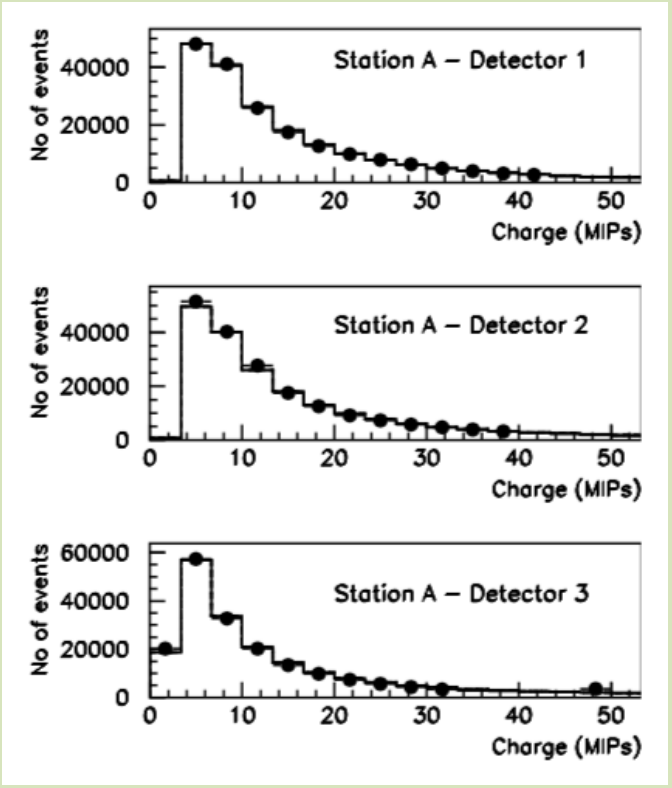


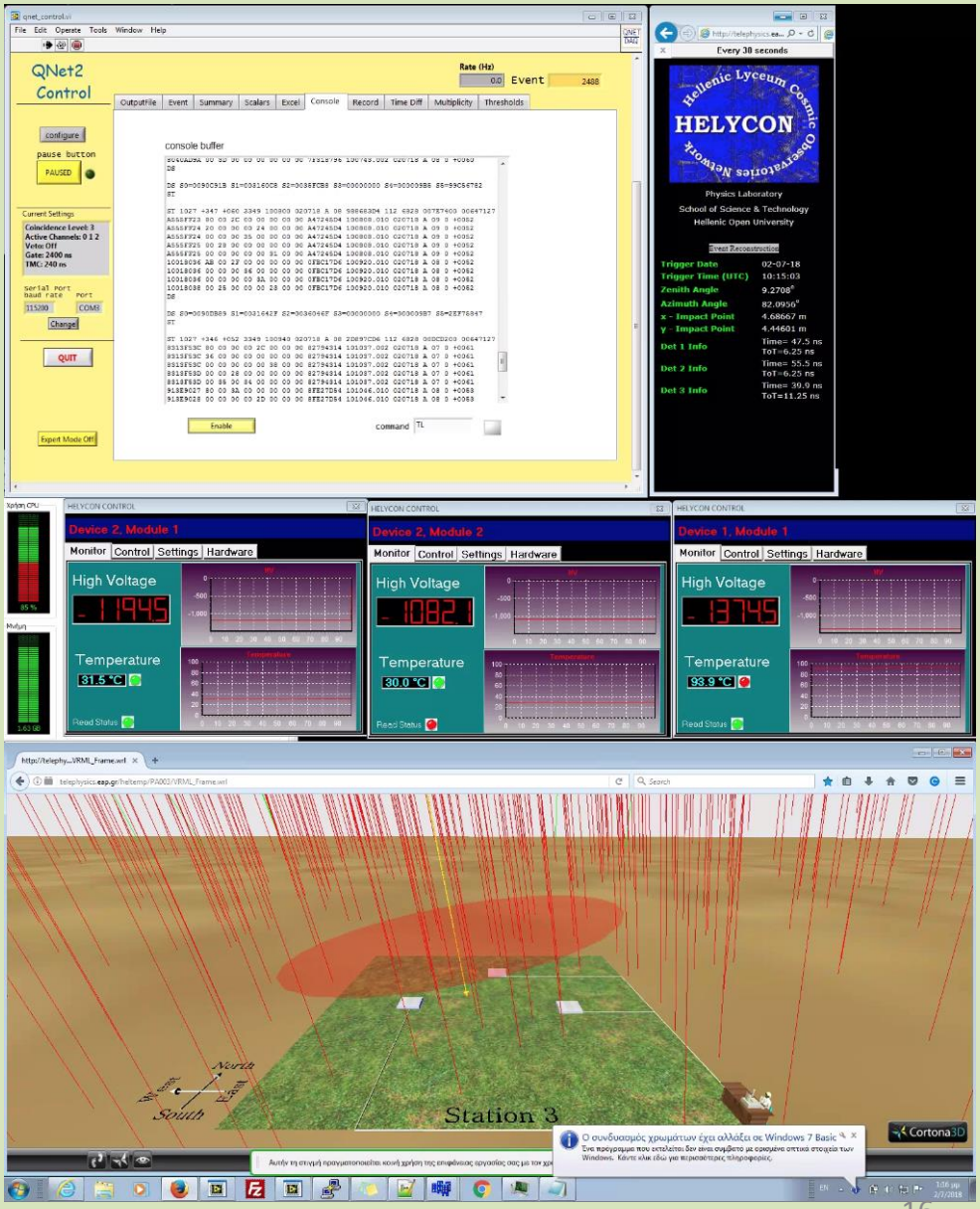


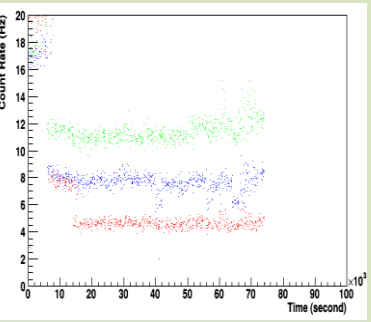
- Parameterizations using Geant4 full simulation
- Slewing correction
- Digitization DAQ functionality
- Signal processing
- Reconstruction Studies

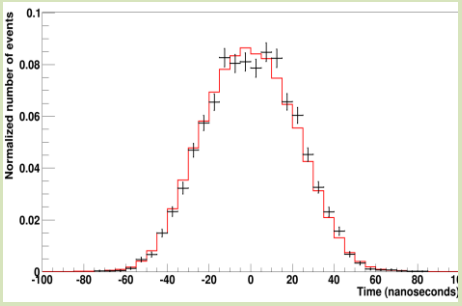
arXiv:1702.00945

Online Software

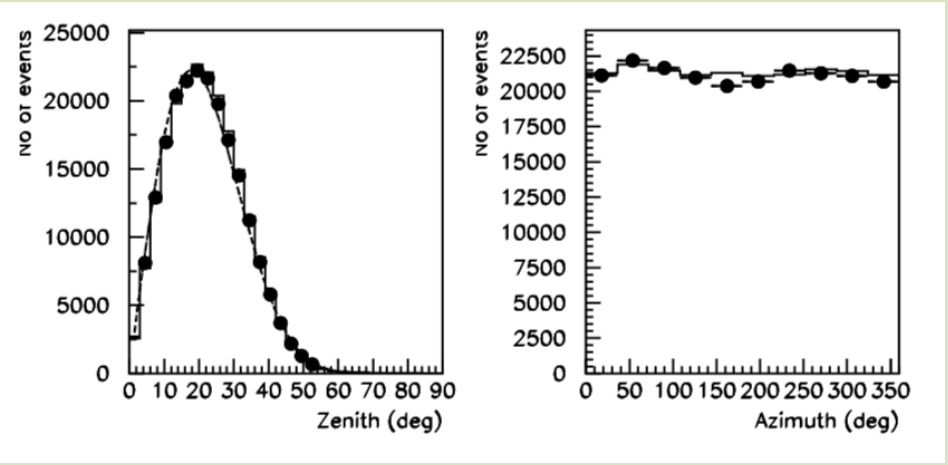


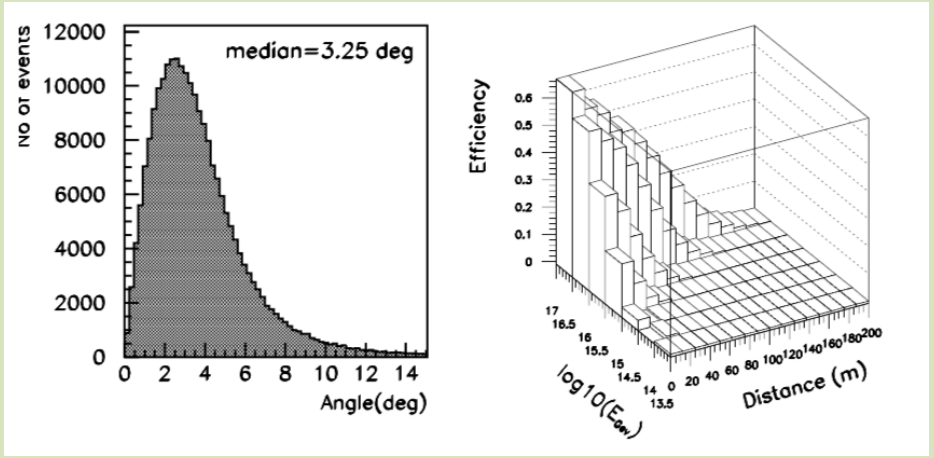






Performance of the HELYCON stations

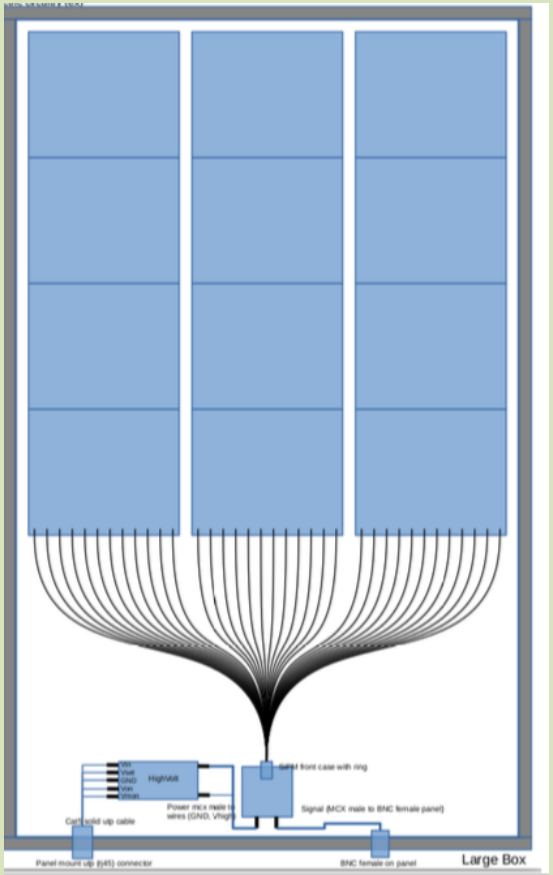


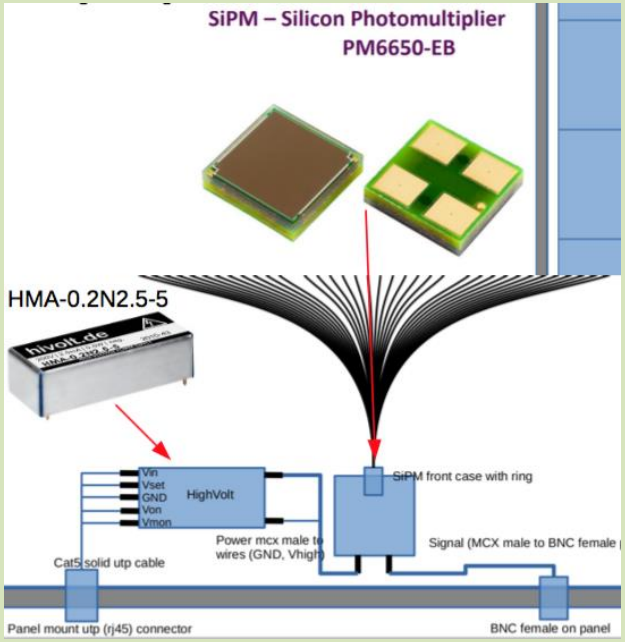


station	Event Rate (hr^{-1})	σ_θ (deg)	σ_ϕ (deg)	ω_{median} (deg)	E_{th} (TeV)
A	17.5	3.3	10.4	3.3	20
B	11.5	6.0	14.8	5.5	30
C	18.9	3.7	11.2	3.6	20

µCosmics
A portable HELYCON station

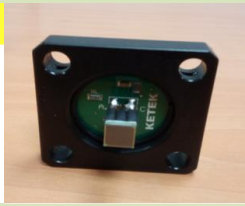
- Portable (67x42x7 cm^3, light (6 kg)
- No high voltages (<40 V)
- Easy to construct

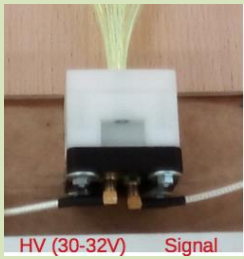




The SiPM

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





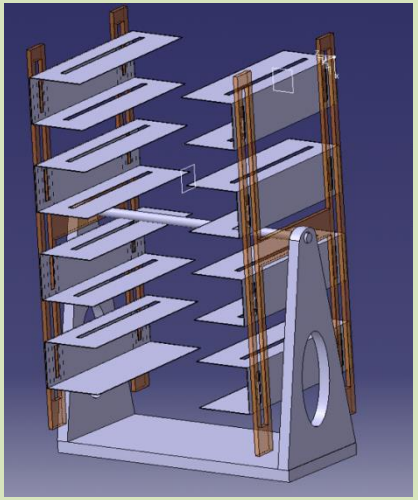
LucidControl AO4 for the control of the HV supply through UTP cable
-4 Channel Analog Output USB Module
-Output voltage 0-5V
-Controls up to 4 detectors (a station)

The power supply of the SiPM

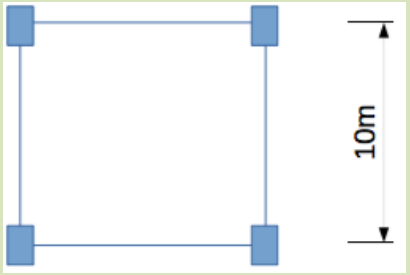
HMA-0.2N2.5-5

µCosmics
A portable HELYCON station

Integrated detector

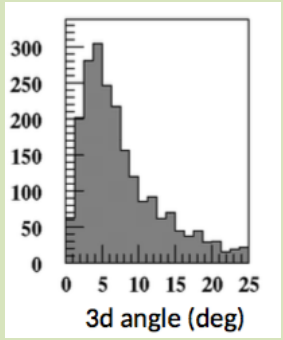


Performance – MC studies of a station with 4 detectors – Resolution and event rate – II



Square 10x10

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



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

Summer School for Astroparticle Physics 25-29 June 2018

- 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

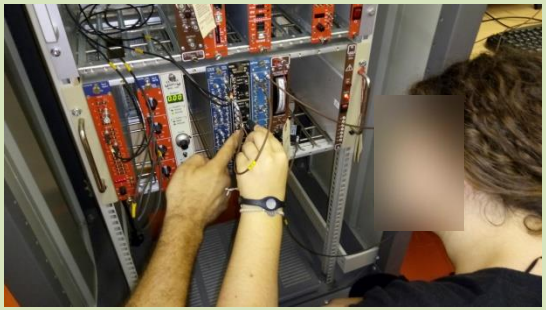
Testing the connections

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

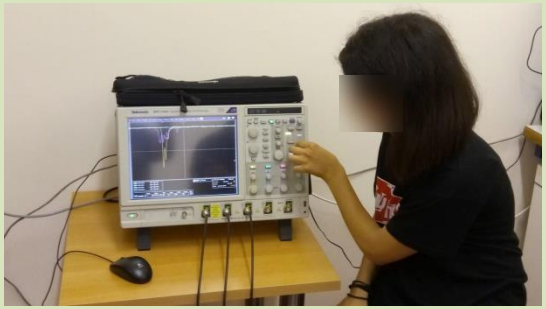
DAQ

Review

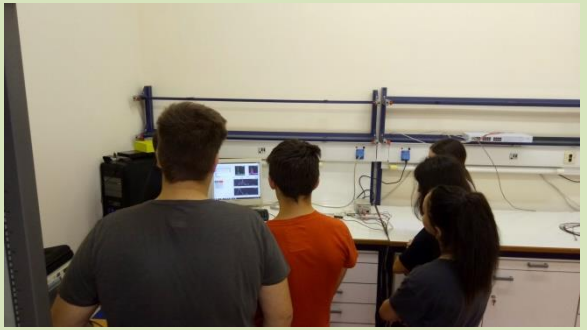
3rd Group: Response of a HELYCON detector

DAQ training

Measurements



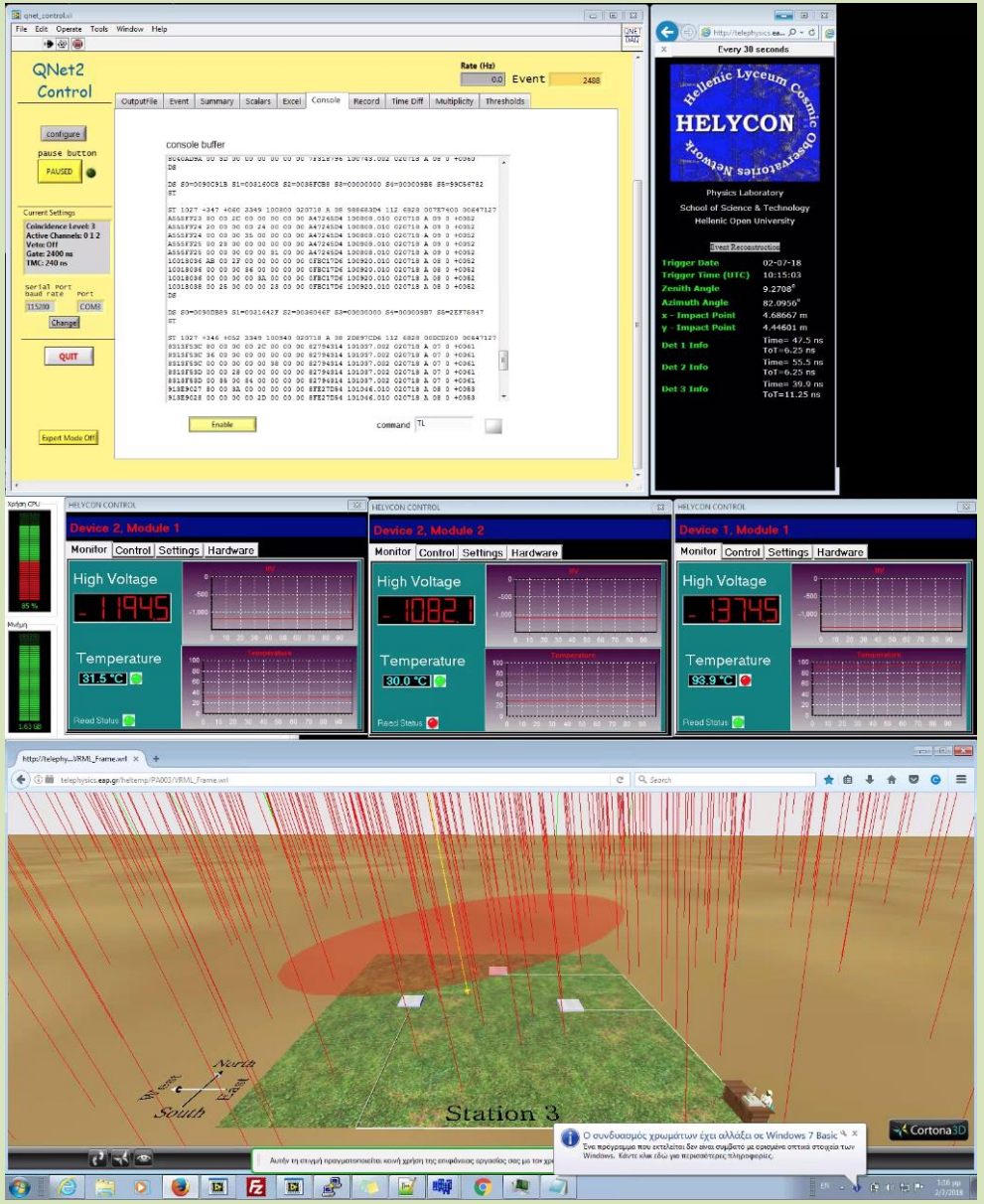
Acquisition



Experimental Setup

Preparing the report

Operation of a station



Some conclusions

- Students really enjoyed it.
- Especially the 1st group (construction of μCosmics)
- There were complaints because they would prefer to participate in all three activities
- Didn't like very much the 1st 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