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LICEO SCIENTIFICO STATALE
"Arcangelo Scacchi"

COSMIC RAYS RATE
AT DIFFERENT ALTITUDE VALUES
A PRELIMINARY REPORT
EEE RUN COORDINATION MEETING, 05/24/2023

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ABOUT US

We are the students of EEE Junior Group of Liceo Scientifico Statale "Arcangelo Scacchi" in Bari.
We have prepared for this experiment attending some starting lessons with our team teachers and some focused lectures on radiation and particles detectors @ the INFN Section of Bari.

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OUR EXPERIMENTAL AIM

The aim of our experiment is to detect secondary cosmic rays by means of a small detector called "Cosmic Box" .
We divided into 3 groups to measure and analyze the frequency of events in 3 lsites at different altitude, pressure and temperature.
This esperiment is similar to the measument performed by the EEE students in Sicily during The EEE CONFERENCE IN ERICE- december 2017

- *Selva of Fasano* a small town surrounded by forests of oaks, pine, chestnut and cypress. (400 m.a.s.l)
- *Grotta del Trullo*, a karst cave in Putignano (350 m.a.s.l.)
- *Porto Rosso* a beach in Monopoli enclosed by rocky shores (3 m.a.s.l.)

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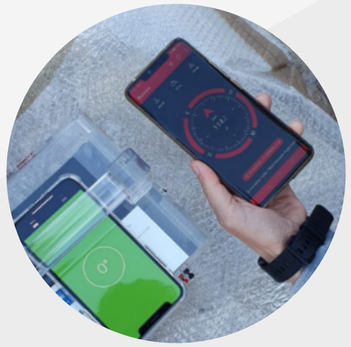
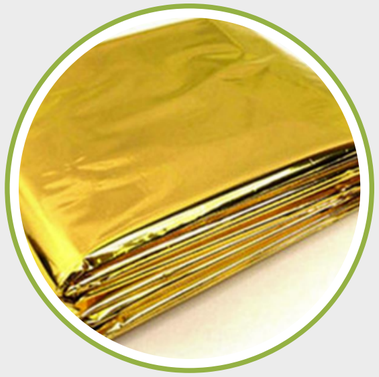
SET UP AND DEVICES

COSMIC BOX: the portable particle detector.

POWER SUPPLY: a power bank powered at 5V

THERMAL BLANKET: an aluminum cover to protect the CB from external noise (sunlight and e.m. waves).

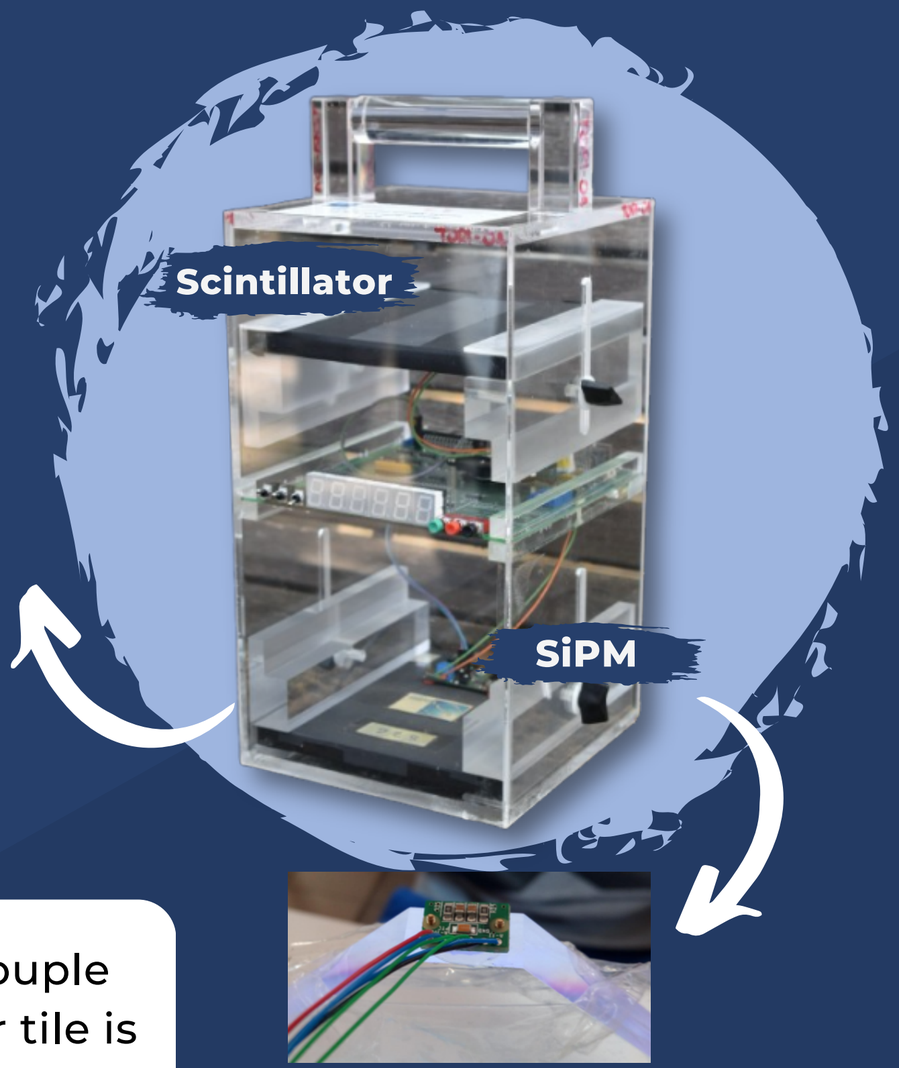




CELL-PHONE : used to record geographic coordinates (longitude, latitude, altitude), to measure temperature, pressure and time intervals, to verify the box to be in plane.

THE COSMIC BOX

The surface of scintillator is
- painted with reflective coating
- wrapped with a reflective film



To reduce noise 1 couple SiPMs per scintillator tile is installed

A cosmic box is a portable particle detector that allows us to directly measure cosmic rays.
It consists of two parallel scintillator tiles (15 cm x 15 cm x 1 cm) placed at a variable distance (usually about 30 cm).

The process is based on the production of photons by the ionization energy loss following the excitation and de-excitation of electrons

- When a particle passes through a scintillator it releases part of its energy as a photon.
- The photon is converted by a SiPM into an electric signal.
- The cosmic ray is detected!

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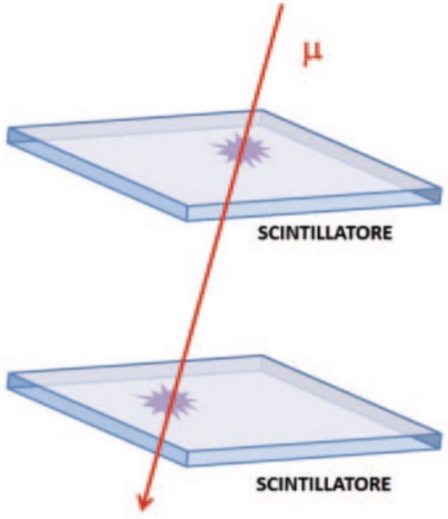
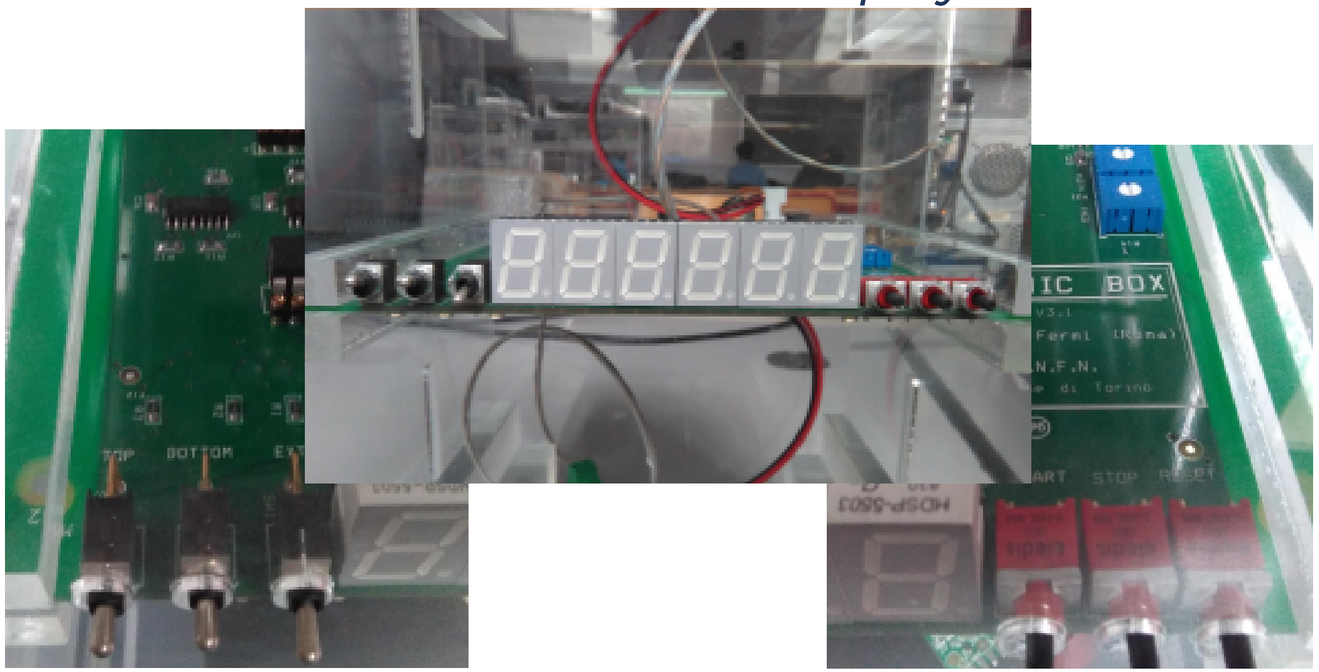
The display to monitor the acquisition rate can be operated with a single and double coincidence trigger

To reduce the spurious events the two detectors are placed in overlapping position for measurements in
coincidence and an event is logged only when the signal is simultaneously emitted by both the scintillators (at the same time). Consequently, all the events when a cosmic particle passes through just one of the scintillators are rejected



Front bottons and display



Selectors for COINCIDENCE logic

Start/Stop/Reset the counter

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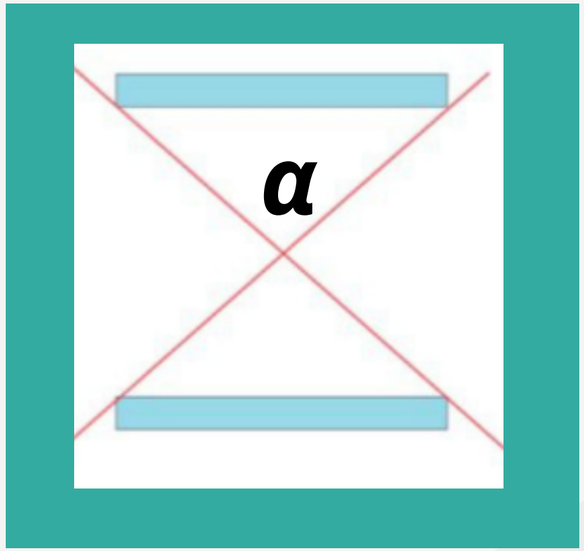
MEASUREMENT

- find a flat surface where laying the CB
- check the acceptance of the CB is not shadowed by any building or wall
- check single coincidence trigger to verify the electronic.
- select double coincidence mode
- protect the box with the aluminum cover

The number of counts were taken during the amount of time of **25 minutes** each time and the scintillators were **17,5 cm** apart from each other.

take note of:

- counts
- start and stop time (with 5 seconds max uncertainty)
- pressure , altitude , temperature (try several measurements with different mobiles using GPS)



In our operating configuration acceptance "α" is about 80°

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SELVA DI FASANO

Latitude: 40° 49' 43'' N
Longitude: 17° 19' 8'' E
Altitude: 400 m above sea level
Weather: sunny with clouds
Temperature: 15,3 °C
Pression: 966 hPa
CB inclination: 2°

GROTTA DEL TRULLO

Latitude: 40° 51' 25'' N
Longitude: 17° 6' 35'' E
Altitude: -20 m under ground level
(350 m above sea level)
Weather: /
Temperature: 14,5 °C
Pression: 974 hPa
CB inclination: 0°

PORTO ROSSO

Latitude: 40° 56' 49'' N
Longitude: 17° 18' 28'' E
Altitude: 3 m above sea level
Weather: sunny
Temperature: 17 °C
Pression: 1012,8 hPa
CB inclination: 3°

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SELVA DI FASANO

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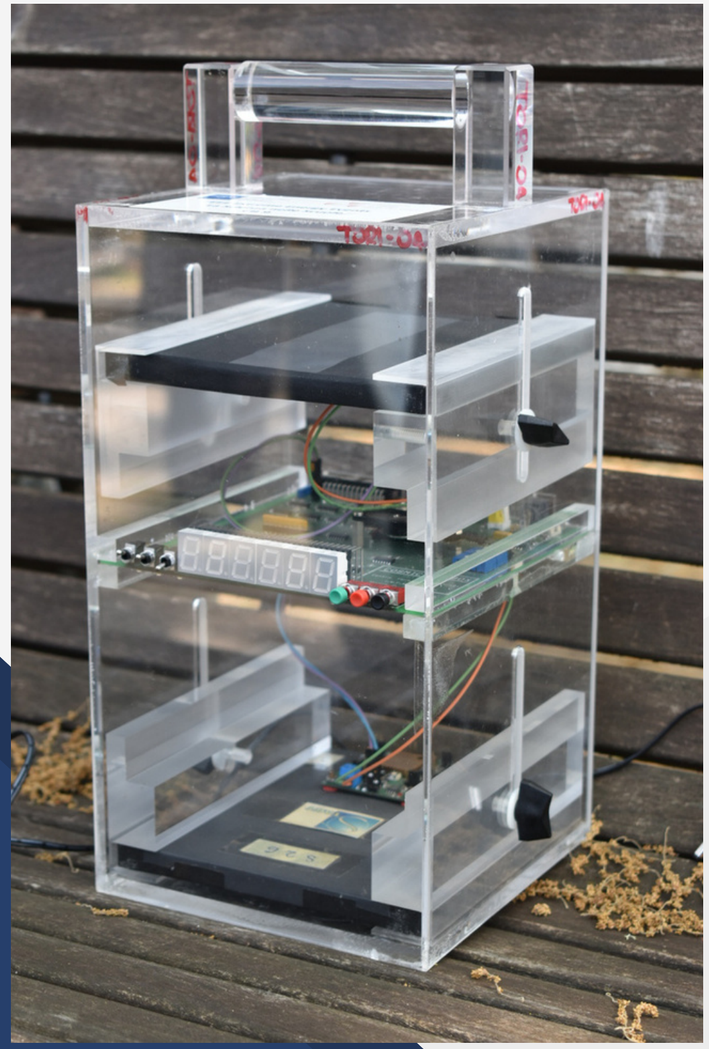

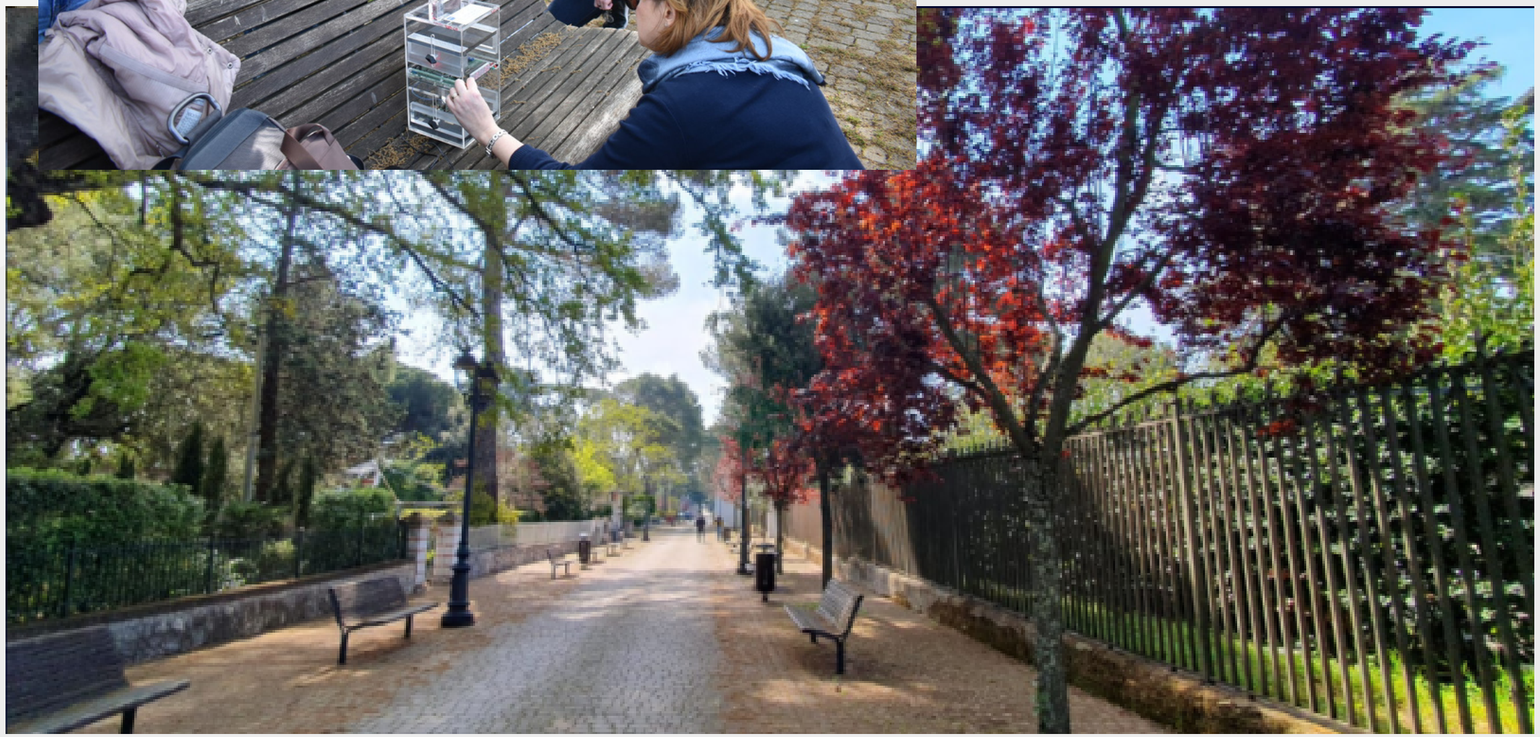

GROTTA DEL TRULLO

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PORTO ROSSO MONOPOLI

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COSMYC RAYS & STATISTIC

The arrival and detection of cosmic rays in a detector is a random process and as such follows a distribution law characteristic of random events: the Poisson's statistical distribution

The probability of observing a number n of such rare random events, in a temporal interval limited and always identical, is:

$$P(n) = e^{-\mu}\frac{\mu^n}{n!} \quad (n = 0, 1, 2, \ldots)$$

with μ the mean value of the number of events per interval.

For a Poisson distribution the standard deviation is equal to the square root of the mean: **σ** = √μ and the best unbiased estimate of μ is simply the number of observed events.
Hence we can estimate the uncertainty on the estimated mean as √n and the relative uncertainty as √n/n.

A feature of the Poisson distribution is that with increasing μ is approximated to a normal distribution (or gaussian) with mean value μ and standard deviation **σ** = √μ.

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DATA

Group	Location	Weather conditions	Altitude (m)		Counts	Absolute uncertainty (σ= √N)	Relative uncertainty ((√N)/N)*100)	Rate (Hz)
1	Fasano	sunny	400	a.s.l	110	10,48	9,53%	0,073
2		cloudy	400	a.s.l	1607	40,08	2,40%	1,071
3		cloudy	400	a.s.l	1550	39,37	2,58%	1,033
1	Grotta	/	-20	under ground level	229	15,13	6,61%	0,153
2		/	-20	under ground level	250	15,81	6,32%	0,167
3		/	-18	under ground level	232	15,23	6,57%	0,155
1	Porto Rosso	cloudy	3	a.s.l	348	18,65	5,36%	0,232
2		cloudy	3	a.s.l	906	31	3,32%	0,604
3		cloudy	3	a.s.l	800	28,28	3,54%	0,533

A bar plot of counts at different sites

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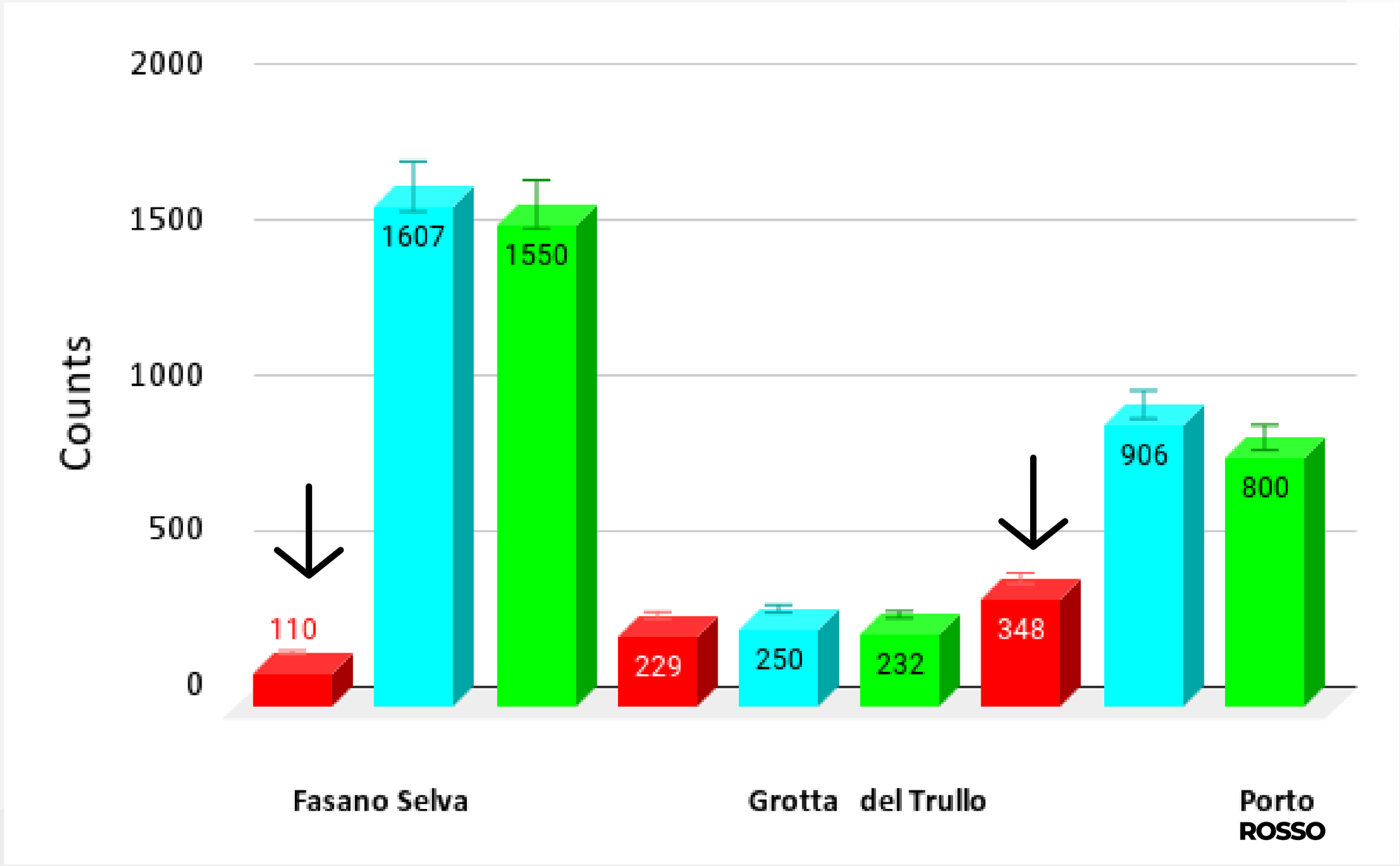

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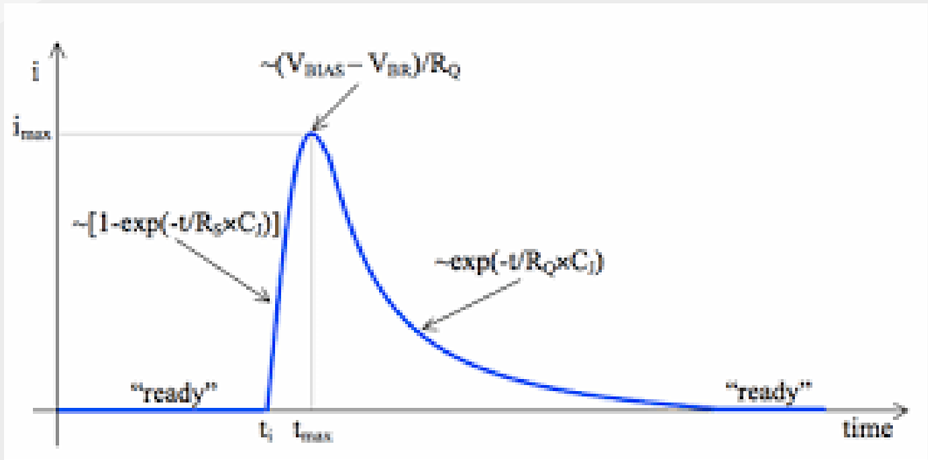
RESULTS

Were the expectations verified?

Data collected in Selva di Fasano, as expexted, show a number of counts greater than measurements performed at sea level. On the other hand, for what concerns data collected in the cave, several layer of rock provides a shield which contributes in decreasing the number of recorded count.

What happens when there is too much sunlight?

From a quick analysis it can be easily deduced that the measurements taken by the first group are incorrect. Despite the use of thermal blanket, this error is most likely caused by the cosmic box which was dazzled by the sun that increased the dead time of the SiPM. We preferred doing measurements in the shade of a tree!



DISCUSSION

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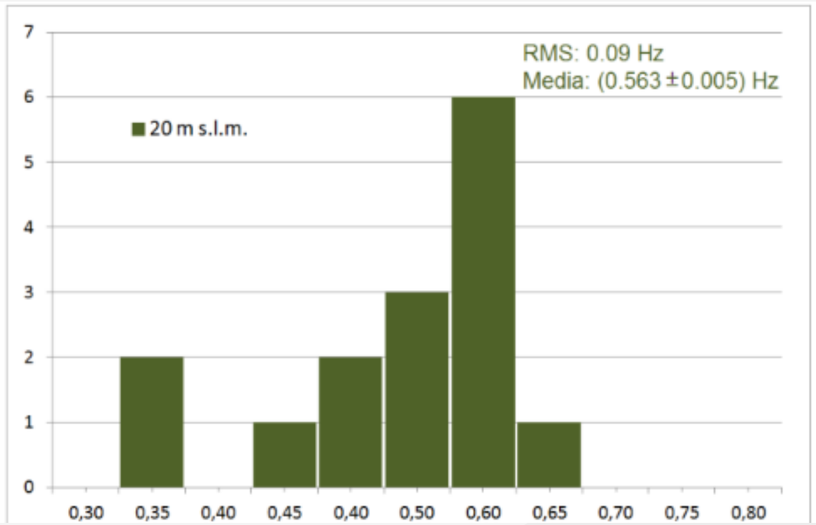
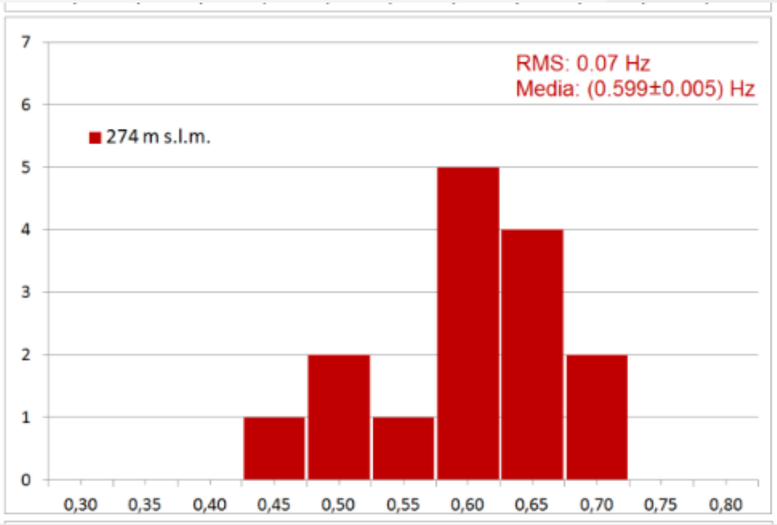
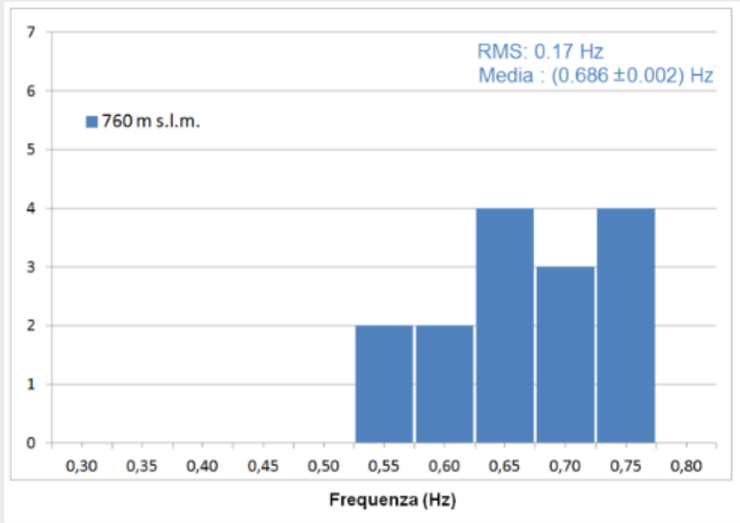
Now, let us compare our results with the results obtained by group of students of EEE project who performed the same experiment in Sicily in 2017 with 15 Cosmic Box, on a temporal slot of 30 minutes, at 20m, 274 m e 760 m above sea level (latitude 38°) . The distance between two scintillators was 30 cm.







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From the Erice's meausements we get, as in reference, a variation of flux equal to: 25%+- 1%/km. Our measurements gives 122%/km, using sea level and Fasano Selva data.

We can assume that this difference might be caused by some factors like:

- effects caused by **sun's modulation**, whose intensity changes over time
- **different methods** used to carry out the experiment

(*Erice's group used 15 cosmic boxes and made a weighted average of rates, taking out values that were over 2 than the average value)*

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ACKNOWLEDGMENTS

- EEE Collaboration for providing Cosmic Box
- Dottor Nicola Mazziotta, INFN Section of Bari for the scientific support.
- Piero Lippolis director of the site " Grotta del Trullo" (https://www.grottadeltrullo.com/it/)

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US AT "WORK"

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- Paola La Rocca: Misura di raggi cosmici mediante Cosmic Box e statistica dei conteggi

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