Extreme Energy Events
Science inside Schools

SCORZA
LICEO SCIENTIFICO STATALE
COSENZA

E.E.E. – Run Meeting:

Cosmic Rays in function of the gas type

Liceo Scientifico “G.B. Scorza” - Cosenza

01 OVERVIEW

Introduction and theoretical notes on the work done.

Who are we?

The following analysis was produced by five students of the “Liceo Scientifico G.B. Scorza” of Cosenza, a school that, since its inception, has actively taken part in the EEE project, adhering to the numerous initiatives which, with enthusiasm, were welcomed by all the students who, in the over the years, they have followed one another within the project.

► Prof. Antonino Zichichi visiting our institute for the inauguration of the laboratory

► Our institute, the «Liceo Scorza»

Furthermore, our institute places its essence in its motto, the famous phrase by Antonino Zichichi, "Bringing science into the hearts of young people" which is the ultimate goal of teachers and above all of the project itself.

► The students at CERN with prof. Zichichi

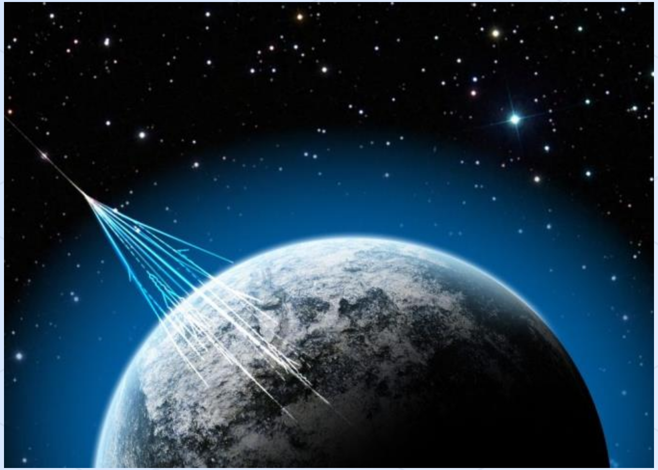
Our institute is equipped with a special laboratory, prepared for activities solely relating to the E.E.E.project, in which the school telescope is located, consisting of three MRPC detectors (Multi-gap Resistive Plate Chamber), built at CERN, assisted by specialized technicians from the first students participating in the project.

► The construction of the telescope

► The school laboratory

The MRPC detector developed by Professor Antonino Zichichi consists mainly of:
- **2 electrodes** to which high voltage is supplied to create a potential difference;
- **5 intermediate glasses** to divide the thickness of the gas into 6 gaps;
- **2 reading electrodes** segmented into 24 conductive strips;
- **1 aeriform mixture** (98% $C_2H_2F_4$, 2% SF_6).

What are Cosmic Rays?



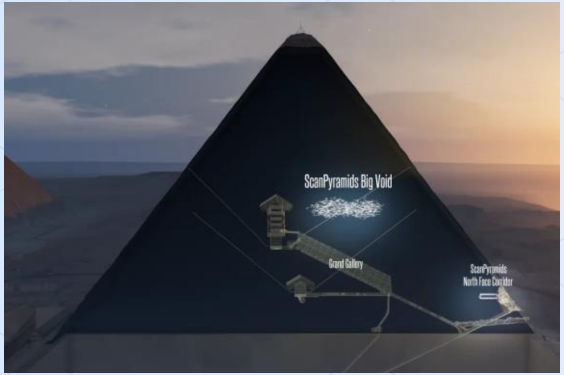
► A digital depiction of cosmic rays.

Cosmic Rays are particles that interact with the earth constantly and from every direction. They are endowed with energy and their provenance is both galactic and extragalactic in nature. The Cosmic Rays of our galaxy are thought to originate in the Supernovae which produce and accelerate them.

Composition

» Primary Component:
- Protons;
- Helium;
- Heavier elements.

» Secondary Component:
- Electrons;
- Muons;
- Pions;
- Neutrinos.



► A section of the pyramid

What can they do?

In addition to the various studies that attempt to demonstrate interference on the climate, by cosmic rays, the actual use can be found in various fields of human knowledge.
Thanks to cosmic rays and muons, two new chambers have been discovered in the Great Pyramid of Pharaoh Cheops, in Giza.

The research began by placing several muon detectors in different points of the pyramid, both inside and outside: the first step was to verify whether the queen's, king's and a long corridor's rooms were whose existence and location was known, were correctly revealed and detected by the system, and so it was;

► A photo of the researchers inside the pyramid

► Our MRPC detector.

How can they be detected?

One of the most diffused class of particle detectors is filled with gas. Basically, they're made out of one (or more) gas volumes, where an electric field is applied.

- Among the first and most popular detectors used for the detection of charged particles;
- They exploit the ionization produced by the passage of a charged particle in a gas.

But, above all, the beating heart of the detector is none other than the gaseous mixture.

The gas mixture of the EEE detectors, before ecological transition, was made out of:

- $C_2H_2F_4$ = Tetrafluoroethane (R134a), a kind of Freon (that's a commercial name for many various gases used mainly for refrigeration) and there's where most ionization and multiplication processes take place.

- SF_6 = Sulfur hexafluoride, used to "quench" the mixture, namely reduce the formation of streamers.

THE ECOLOGICAL PROBLEM

What's the problem with them? They are greenhouse gases, and they have an effect similar to CO2, but much larger.

An example

One EEE telescope, using about 1 L/h of $C_2H_2F_4$ and SF_6 consumes 8760 Liters per year that corresponds to inject into the atmosphere, each year, of:
36.5 kg of $C_2H_2F_4$ and 1.1 kg of SF_6 .

So, one EEE telescope injects into the atmosphere gas, for a GWP equivalent to **78.5 tonnes of CO_2 per year**.
In conclusion, compared with CO_2, $C_2H_2F_4$ and SF_6 have similar effects, but much larger.

NEW GASSES

So it was necessary to replace R134a and SF_6 with more ecological gasses, so with a lower GWP (Global Warming Potential), but:

POINT NO.1

at the same cost.

POINT NO.2

with the same performance.

POINT NO.3

without changing anything of the rest of electonic circuits

FURTHERMORE

- **It must** be a binary mixtures, since we have just two flowmeters;
- **It must** have the working point close to the present, < 20kV
- **It must** Guarantee the same spatial and time resolutions;
- **It must** be safe (we cannot use hydrocarbons);
- **It must** have the same cost (for the whole network ≈ 50 k€/year)

So the substitutes that will make up the mixture for the detectors are:

- **$C_3H_4F_4$ze**, which GWP = 4
  (in spite of GWP_{C2H2F4} = 1430)

  ↗ *($C_3H_4F_4$ze is the most similar molecule to $C_2H_2F_4$ but with a low GWP)*

- **CO_2**, which GWP = 1
  (in spite of GWP_{SF6} = 23900)

or

- **He**, which GWP < 1
  (in spite of GWP_{SF6} = 23900)

RESULTS?

A mixture made out of **$C_3H_4F_4$ /CO_2 50/50** would have **GWP = 2.5**
An EEE telescope would inject in the atmoshpere a gas whose GWP would be equivalent to **89.5 kg/year of CO_2**, correspond to the CO_2 injected yearly by 0.014 human beings living in the EU.

02

ANALYSIS

Is it possible that the efficiency of the gases is different from each other and that therefore there is a difference in the quality of the data produced?

DATA ANALYSIS

While waiting for the complete data that will certainly allow us to complete the data analysis in the best possible way, we have produced a first sign of observation.

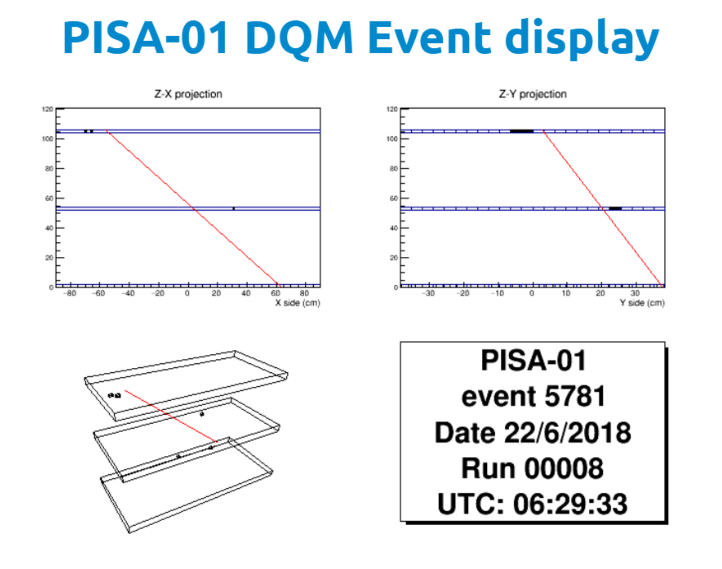
The data analyzed come from the PISA-01 detector which, over the last few months, has experimented with different mix configurations:

» 2^{nd} September 2021 – 5^{th} September 2021:
Pure R134a in all chambers;

» 10^{th} December 2021 – 11^{th} December 2021:
60-40% R1234zeHE (Bottom), R134a (Others);

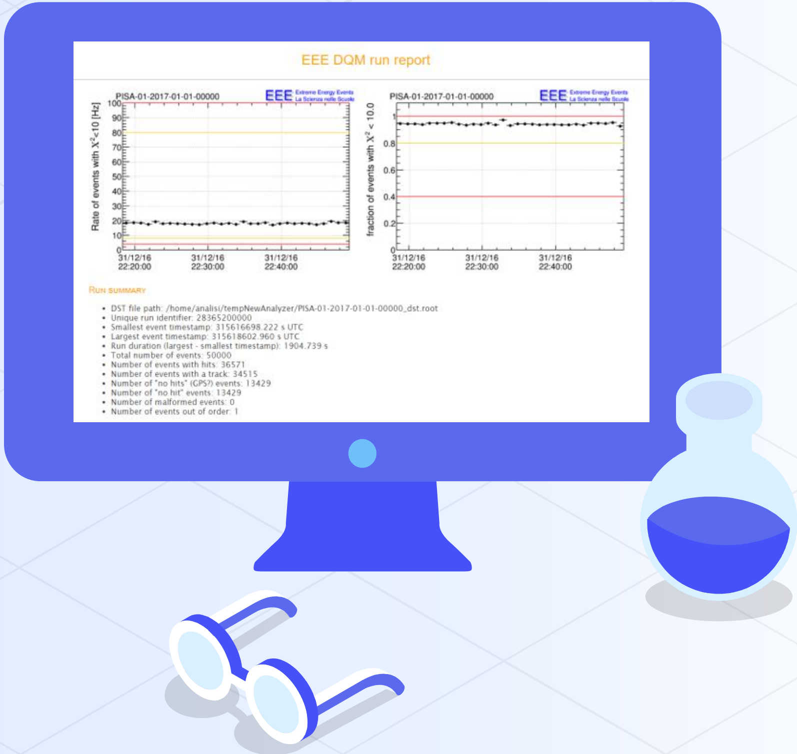
» 26^{th} December – 04^{th} January:
50-50% R1234zeHE (Bottom), R134a (Others).

PISA-01 *[Event Display]*	lun 24 gennaio	17:41	PISA-01-2022-01-24-00020.bin

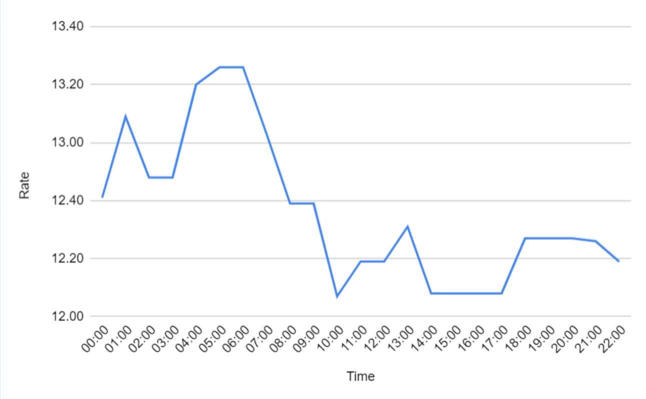


But, having ascertained the lack of sufficient data to conduct a careful analysis of the observations of the Rate as a function of the Gas Volume, we have made several and varied attempts to interpret the data, giving free will to the imagination.

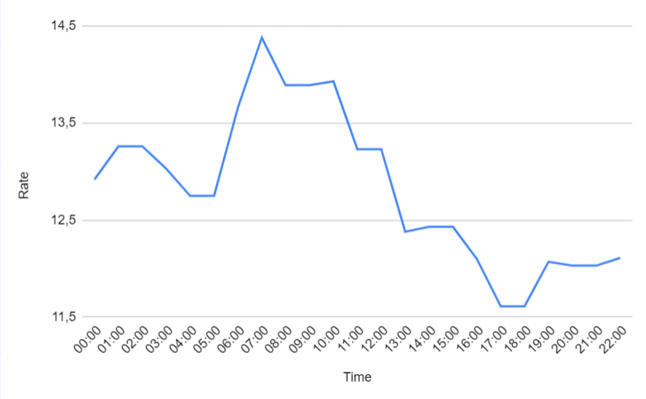
The data used, of course, comes from the PISA-01 official monitor.



First Series: 31/12/2021 – 01/01/2022

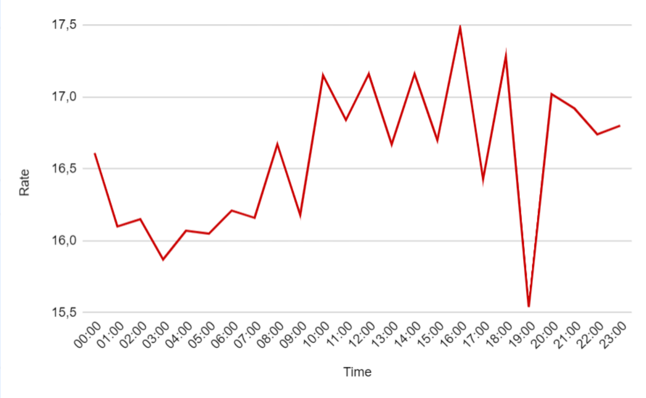


» **Date:** 31/12/2021;
» **Gas:** 50-50% R1234zeHE (Bottom), R134a (Others),
» **Maximum Value (Rate):** 13.20 Hz (05:00 – 06:00 AM);
» **Minimum Value (Rate):** 12.07 Hz (10:00 AM).

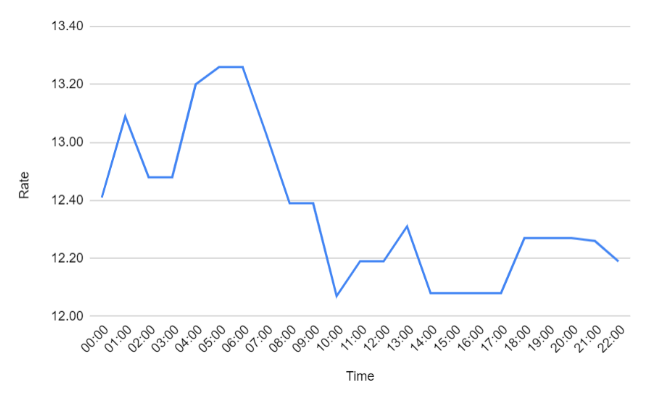


» **Date:** 01/01/2022;
» **Gas:** 50-50% R1234zeHE (Bottom), R134a (Others);
» **Maximum Value (Rate):** 14.38 Hz (07:00 AM);
» **Minimum Value (Rate):** 11.61 Hz (05:00 – 06:00 PM).

Second Series: 31/12/2016 - 31/12/2021

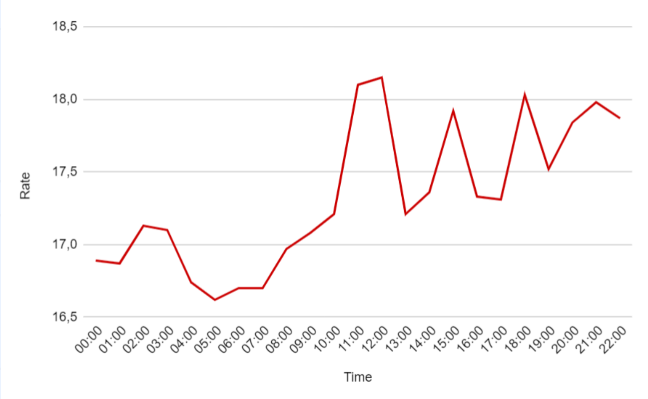


» **Date:** 31/12/2016;
» **Gas:** 98% $C_2H_2F_4$ (Bottom), SF_6 (Others);
» **Maximum Value (Rate):** 17.48 Hz (05:00 PM);
» **Minimum Value (Rate):** 15.54 Hz (07:00 PM).

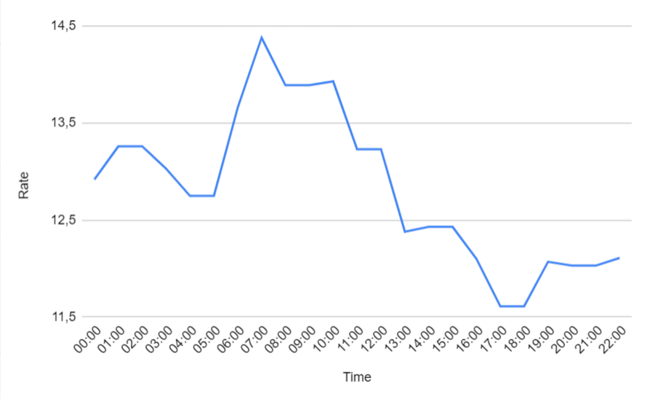


» **Date:** 31/12/2021;
» **Gas:** 50-50% R1234zeHE (Bottom), R134a (Others);
» **Maximum Value (Rate):** 13.26 Hz (05:00 – 06:00 AM);
» **Minimum Value (Rate):** 12.07 Hz (10:00 AM).

Third Series: 01/12/2017 - 01/12/2022



» **Date:** 01/12/2021;
» **Gas:** 98% $C_2H_2F_4$ (Bottom), SF_6 (Others);
» **Maximum Value (Rate):** 18.15 Hz (12:00 AM);
» **Minimum Value (Rate):** 16.62 Hz (05:00 AM).



» **Date:** 01/12/2022;
» **Gas:** 50-50% R1234zeHE (Bottom), R134a (Others);
» **Maximum Value (Rate):** 14.38 Hz (07:00 AM);
» **Minimum Value (Rate):** 11.61 Hz (05:00 – 06:00 PM).

THANKS FOR ATTENTION!

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