DISCOVERY OF COSMIC RADIATION: PACINI,HESS EXPERIENCE

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THE FIRST OBSERVATION...

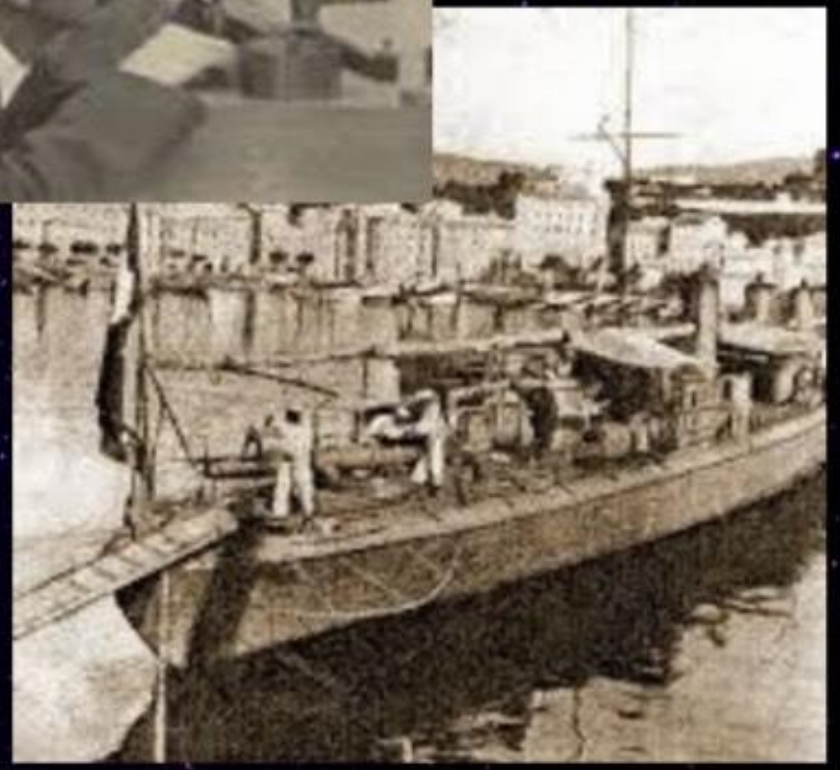
In recent years, physicists discovered the existence of natural radioactivity, that is, the spontaneous emission of particles by some materials, using electroscopes. The speed of electroscope discharge was due to the presence of more or less intense radioactivity in its proximity. It was natural to imagine that this radioactivity had a terrestrial origin. Therefore, to test this hypothesis, scientists started to move electroscopes up, as far from the ground as possible, to see if the radiation was decreasing.

1910

Father Theodore Wulf was the first to investigate the phenomenon systematically and with a particularly high-quality electroscope. He chose to take measurements on the top of the Eiffel Tower, 300 meters above the park below. As soon as he turned on the instrument, he was astonished to find that the signal provided by the electroscope was not what he had imagined.

DOMENICO PACINI

Among the various scientists who investigated the phenomenon, an important role was played by the Italian physicist Pacini who for the first time thought of placing detectors not above but under the surface of the water, paving the way for what was then experimentation in underground laboratories. His results suggested again that the source of this mysterious radiation that acted on the electroscopes should not be linked to the Earth's soil.

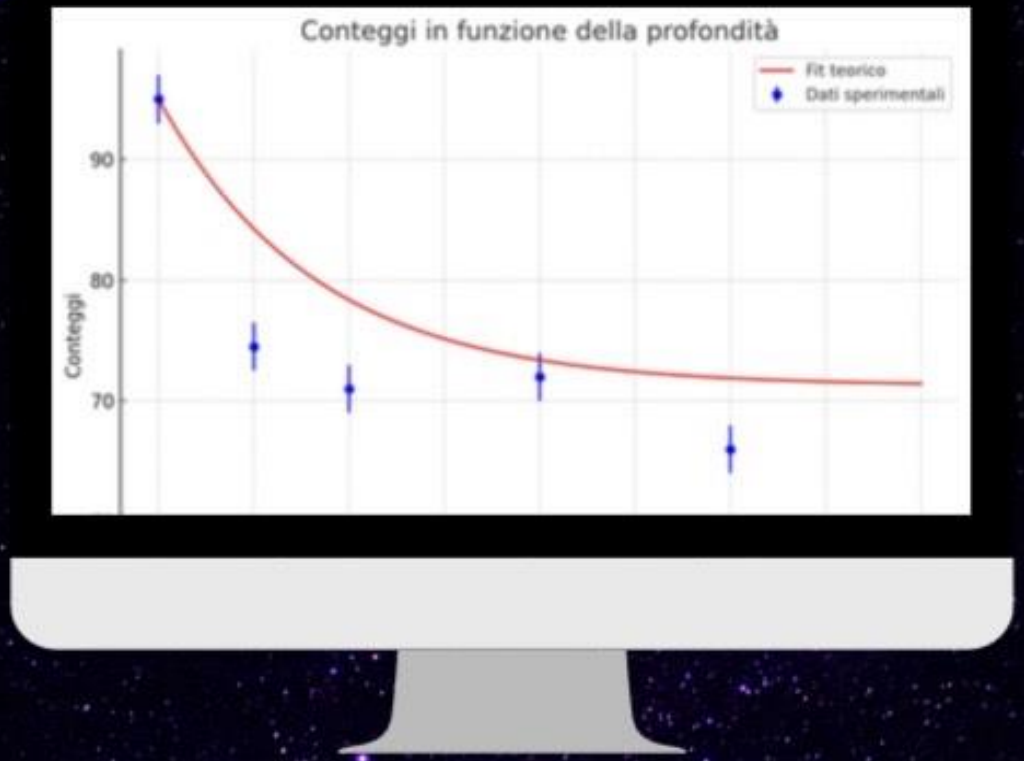


Experiment Description:

The experiment measures the intensity of the signal at different depths of immersion in water, to understand if the common thought about the origins of radioactivity was true

Observations:

- The number of counts decreases with increasing depth, as predicted by the model.
- At depths greater than 2 m, the counts stabilize, suggesting a less marked attenuation after a certain threshold.
- The data are in good agreement with the model, confirming the exponential trend of the attenuation.



Where does this data come from?

To further explore Domenico Pacini's experimental contribution, we analyzed the data collected in a teaching activity inspired by his experiments, conducted by students of the Livorno Scientific High School

As the depth increases, the radiation decreases according to an exponential function.

How did we calculate the errors?

The errors on the counts were calculated using the Poisson statistic, which is fundamental for counting random events. In fact, if N is the number of counts, the associated error is: $\Delta N = \sqrt{N}$

Profondità (m)	Conteggi
0	95
0,5	74,5
1	71
2	72
3	66
4	56

THE EXPECTED RELATIONSHIP IS:

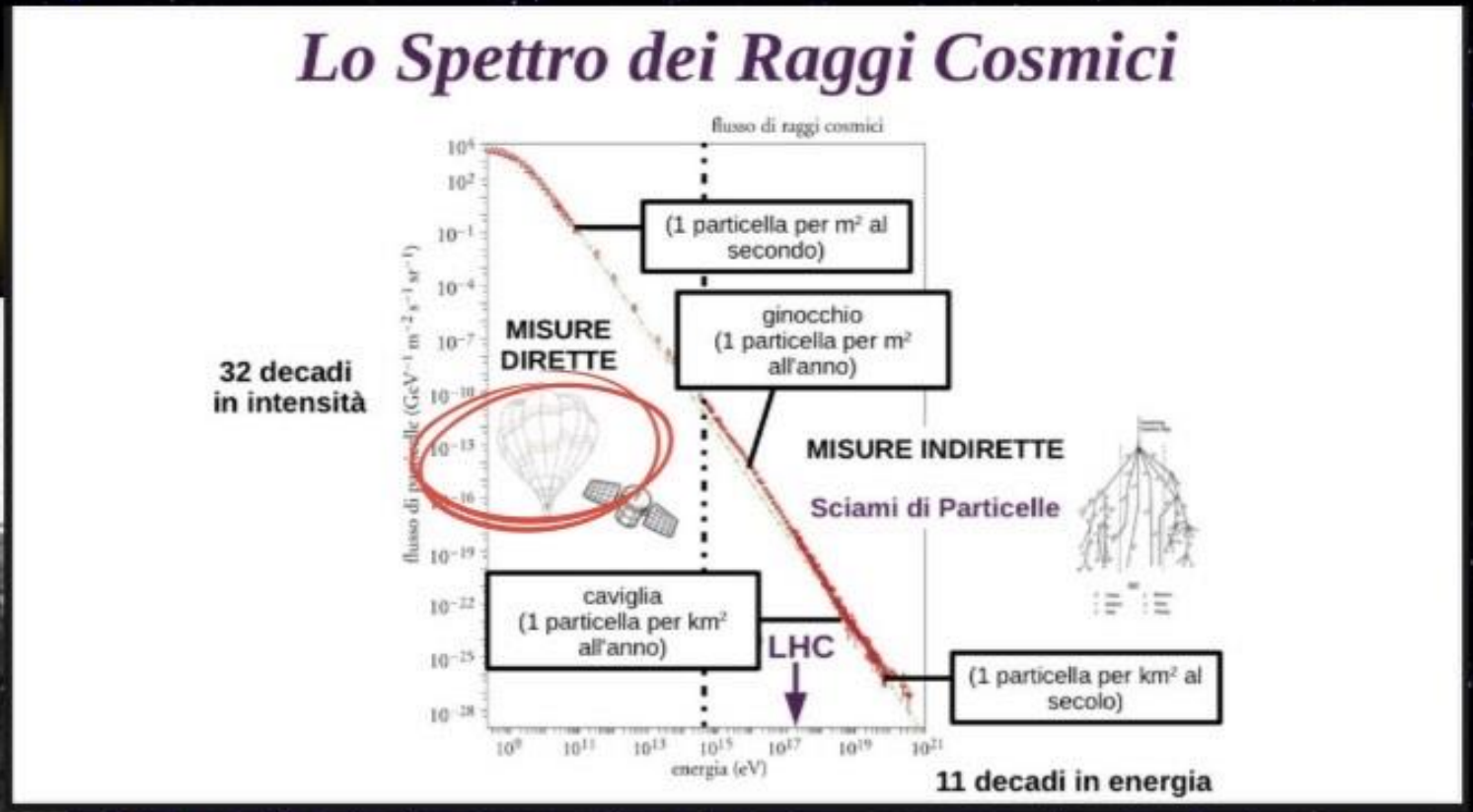
$$\frac{R}{R_0} = 1 - f\left(1 - e^{-d/H}\right)$$

- R represents the count detected at a depth d;
- Ro is the count at zero depth (reference value);
- f is the attenuation factor, which indicates the fraction of the attenuation effect
- H is the characteristic depth, i.e. the scale on which the absorption effect becomes significant

VICTOR HESS

AND THE DISCOVERY OF COSMIC RAYS

August 7, 1912



In 1912, the Austrian physicist Victor Hess decided to carry out a new experiment. It involved taking the instrument to thousands of meters of altitude with a hot air balloon. He observed that, as the balloon rose from the ground, the level of radiation decreased much more slowly than expected, until it stabilized around 700 meters. Starting from 1500 meters of elevation, the signal began to grow again until, at 5000 meters from the ground, it reached a level even double compared to the background signal measured on the ground. So it was that the scientific community, thanks to Victor Hess, measurements the scientific community understood that a radiation of unknown origin came from space penetrating the Earth's atmosphere

CONCLUSION:

In conclusion, the experiments of Domenico Pacini and Victor Hess revolutionized our understanding of ionizing radiation, demonstrating the existence of cosmic rays.
Pacini, with measurements in water, showed that part of the radiation was not terrestrial; Hess confirmed this hypothesis with flights at high altitude.
Their work paved the way for particle physics and continues to inspire scientific research today.
Today, the physics of cosmic rays is a fundamental field of research for astrophysics and particle physics, with experiments conducted in observatories such as the Pierre Auger Observatory, which performs measurements at the lowest energies, and the AMS-02 space telescope that instead performs measurements at the lowest energies.