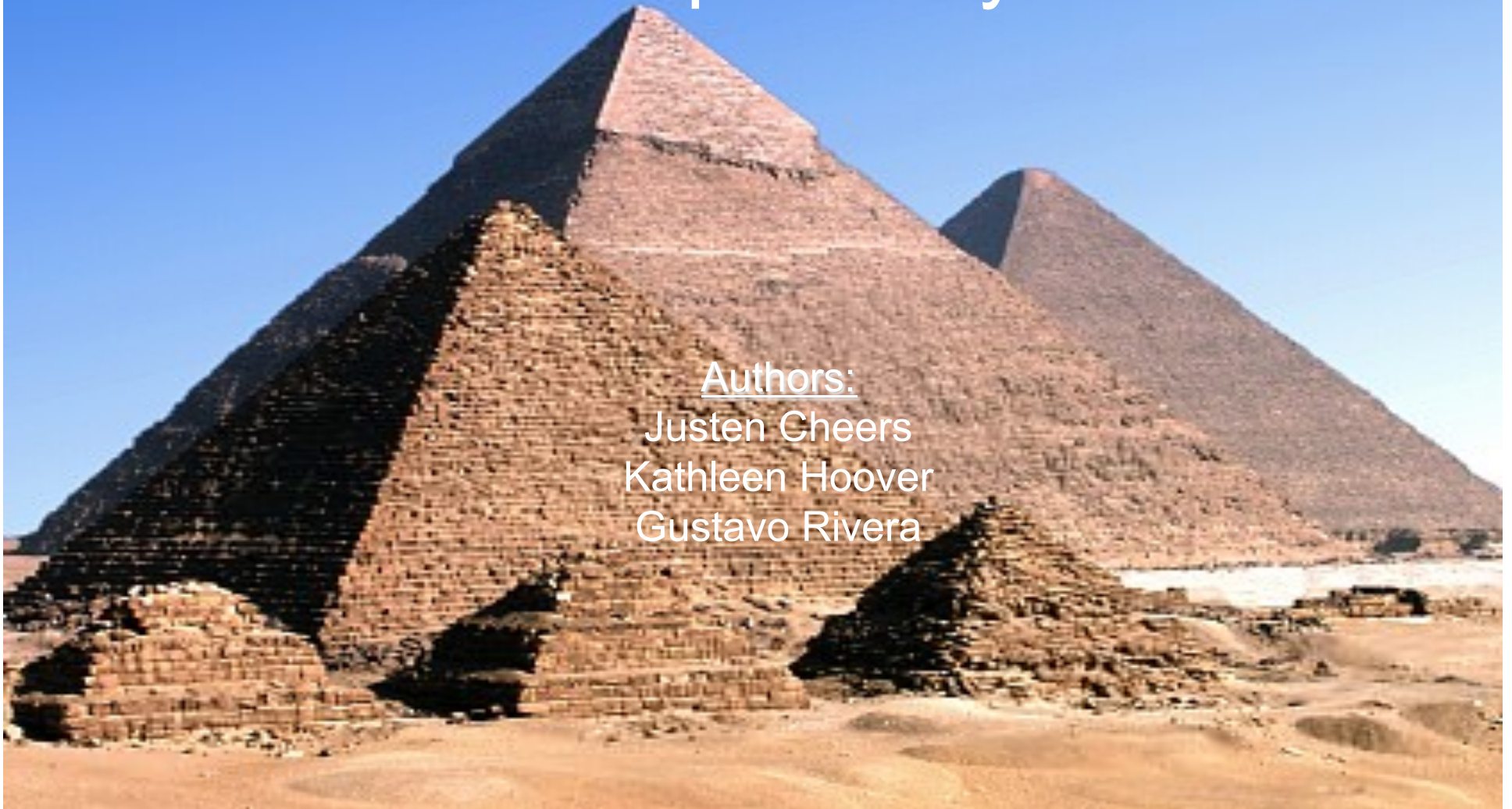


The Alvarez experiment, cosmic ray search for hidden chamber on the Chephren Pyramid

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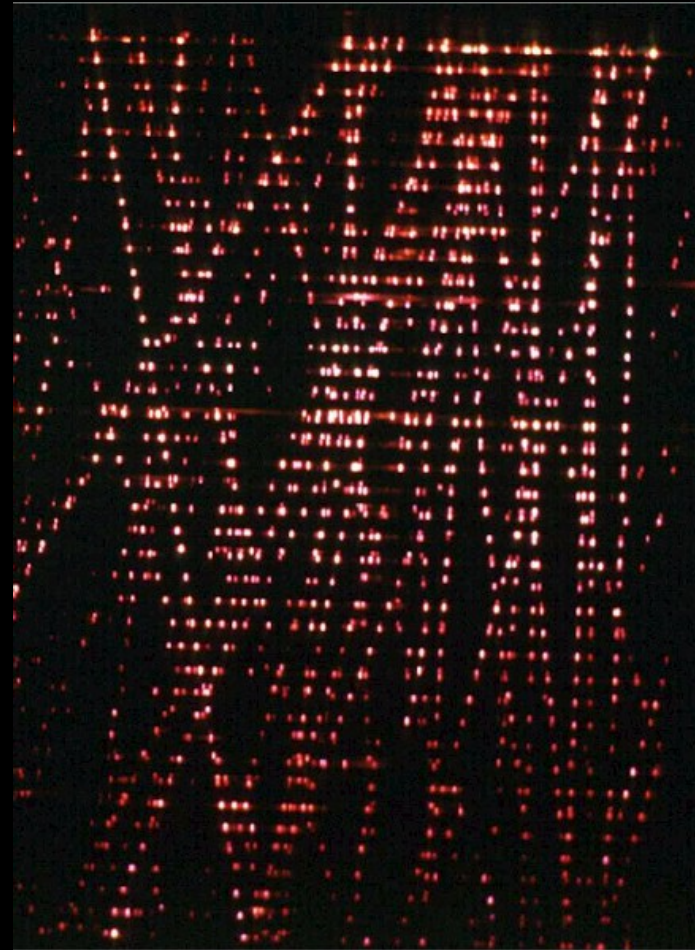
New tools for archeology: Cosmic Rays

- The use of cosmic rays for scientific research started in the 1960s.
- Cosmic rays are generated in stars, galaxies, nebulas, and supernovas.
- Cosmic rays are one of the most powerful sources of natural radiation that exist in the universe.



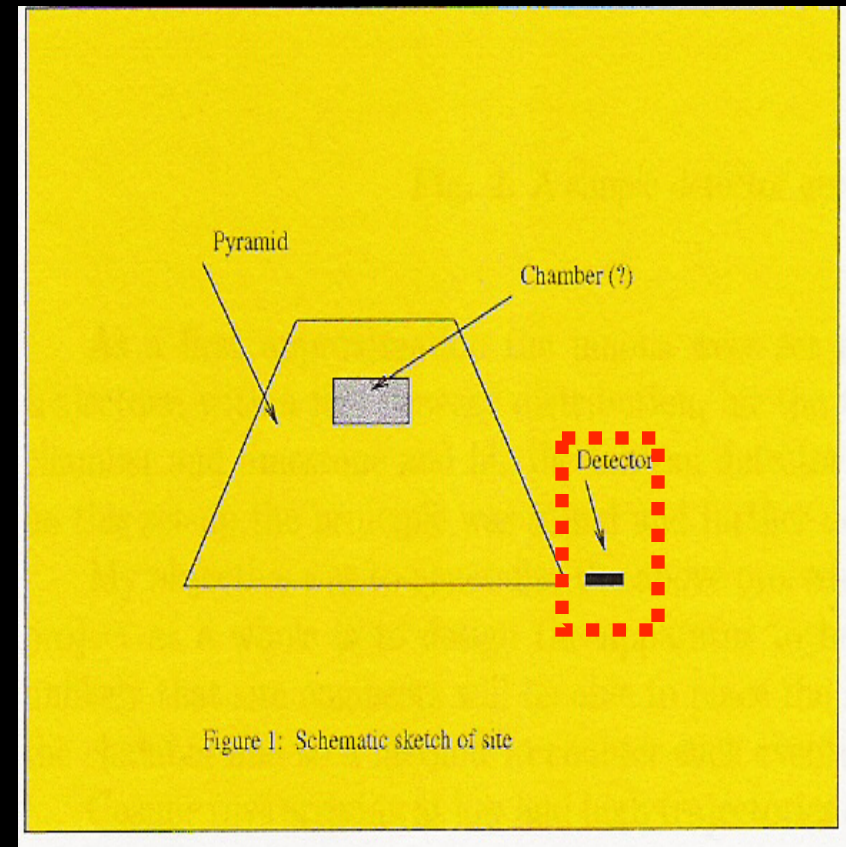
Facts about cosmic rays

- Cosmic rays are created when subatomic particles from outer space collide with the atmosphere.
- Cosmic rays are highly energetic sub-atomic particles, mostly protons and helium nuclei, which travel across space at close to the speed of light.
- Cosmic rays can be up to 10^{21} electron volts, which is more than a billion times more energetic than the most energetic particles that exist on earth.



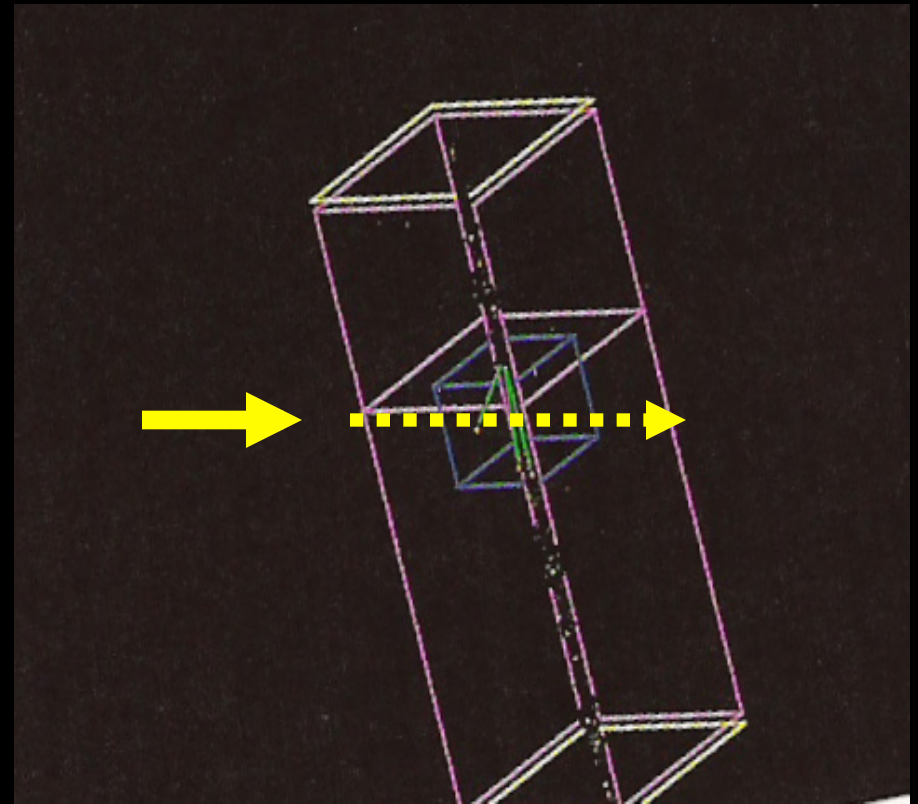
Hypothesis on the existence of secret chambers

- The goal of this technique is to use cosmic rays that are passing through the pyramid to deposit energy on a detector located at the foot of the pyramid.
- As the muons pass across the limestone of the pyramid, they will lose energy because of frequent collision and friction with the structure.

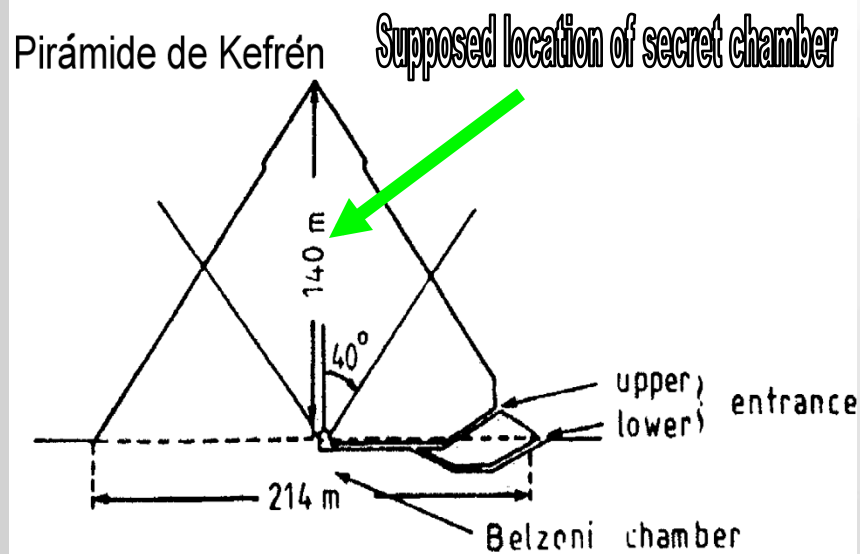


How to identify the existence of a secret chamber

- We would expect to see a higher rate of incidence on the bottom detector for those particles passing through the existing chamber.
- The detector on the bottom can read data of incidence, position, and momentum of the particles.
- Depending on how the trajectory of the particles are and relying on the readings of the detector, if a particle were to pass through the chamber it would noticeably lose less energy through more infrequent collisions with the limestone.



The use of secret chambers in ancient civilizations



- Used to hide the buried bodies of pharos or people who had lots of power.
- The secret chambers were usually blacked off by a huge slab of limestone or other hard rock.
- With the use of secret chambers the pharos' body could be at rest with all his lavishes without the threat of the body or the jewelry being stolen.

Importance of secret chambers



- Secret chambers are a very important piece that the archeologists can use to solve the complex puzzles of ancient civilizations.
- They can provide historical information, as well as spiritual narratives and believes.
- Anthropologists have always believed that the places of burial are very important to understand the way in which different cultures lived.

Dr. Luis W. Alvarez



- Luis Alvarez was born in San Francisco, California, on June 13, 1911.
- Studied in the University of Chicago and worked for a long time in a research team at the Radiation Laboratory of the University of California.
- Dr. Alvarez devoted to work in the areas of optics and cosmic rays.
- Dr. Alvarez was also in charge of three important radar systems during the WWII, and was a scientific observer at the Hiroshima explosion of the Atomic Bomb.

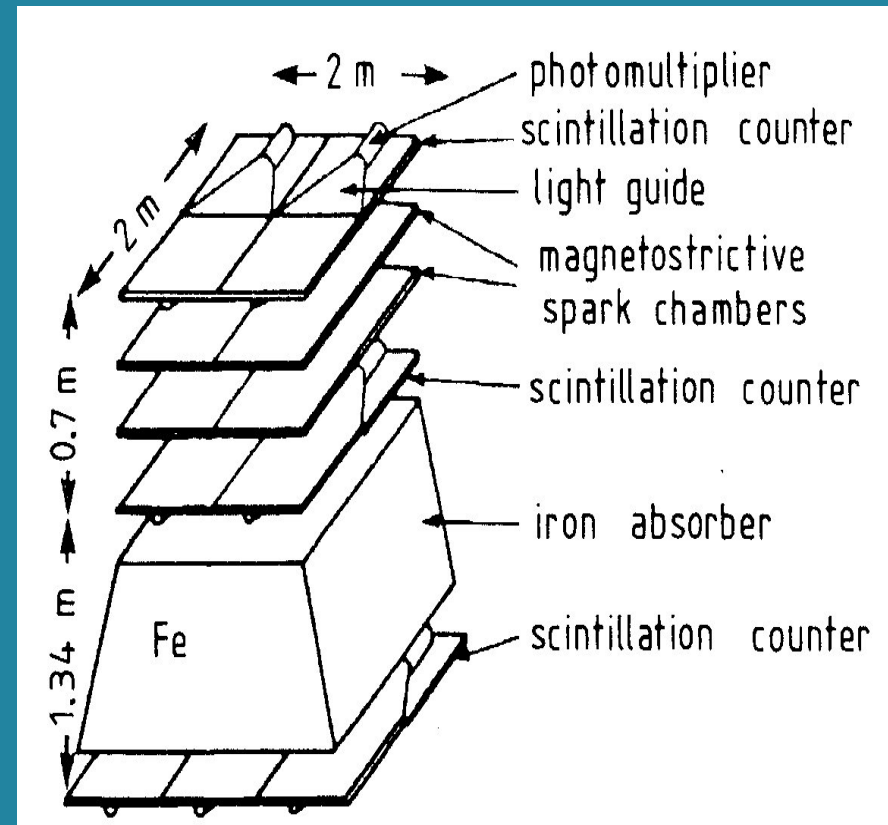
Accomplishments and work of Dr. Luis W. Alvarez



- In 1968, Alvarez received the Physics Nobel Prize.
- During the 1960s that Dr. Alvarez led a series of experiments using cosmic rays in the Chephren Pyramid.
- After working with his son Walter, a geologist at Berkley, developed the hypothesis that an asteroid hit the earth and produced a cloud that covered the planet for a long period of time, blocking sunlight, and eventually leading to the extinction of dinosaurs.

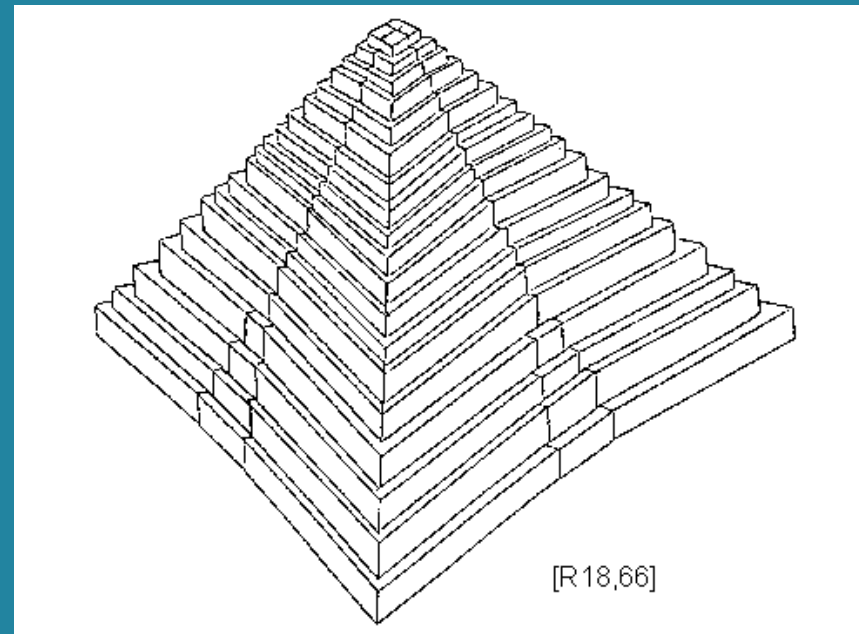
The Alvarez Experiment: Method

- The cosmic rays detectors were installed in the Belzoni Chamber of the pyramid, which is located in the lower-middle section in the interior of the pyramid.
- Millions of cosmic rays penetrated the limestone on their way to the detectors inside the pyramid, in search of evidence on the existence of the secret upper chamber.
- The experiment was repeated many times, and millions of readings of the cosmic rays that went across the pyramid were done.



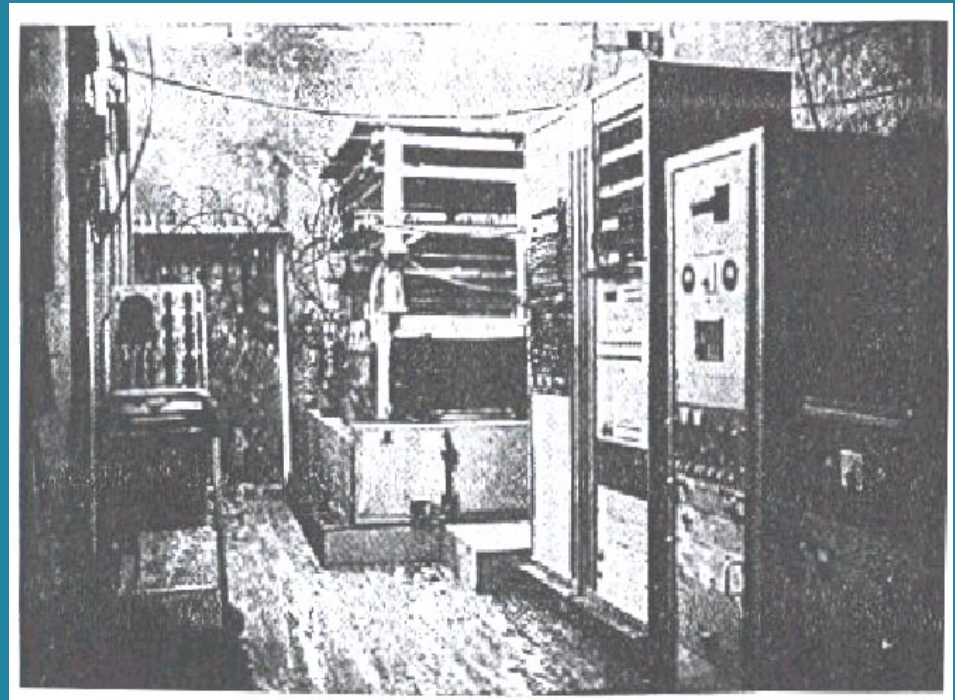
The Alvarez Experiment: Motivations

- Hypothesis about the existence of a secret upper chamber in the Chephren Pyramid, similar to the one inside the Great Pyramid.
- The recent development of cosmic rays technology for archeological research.
- The generous funding provided by the governments United Arab Emirates and the United States.



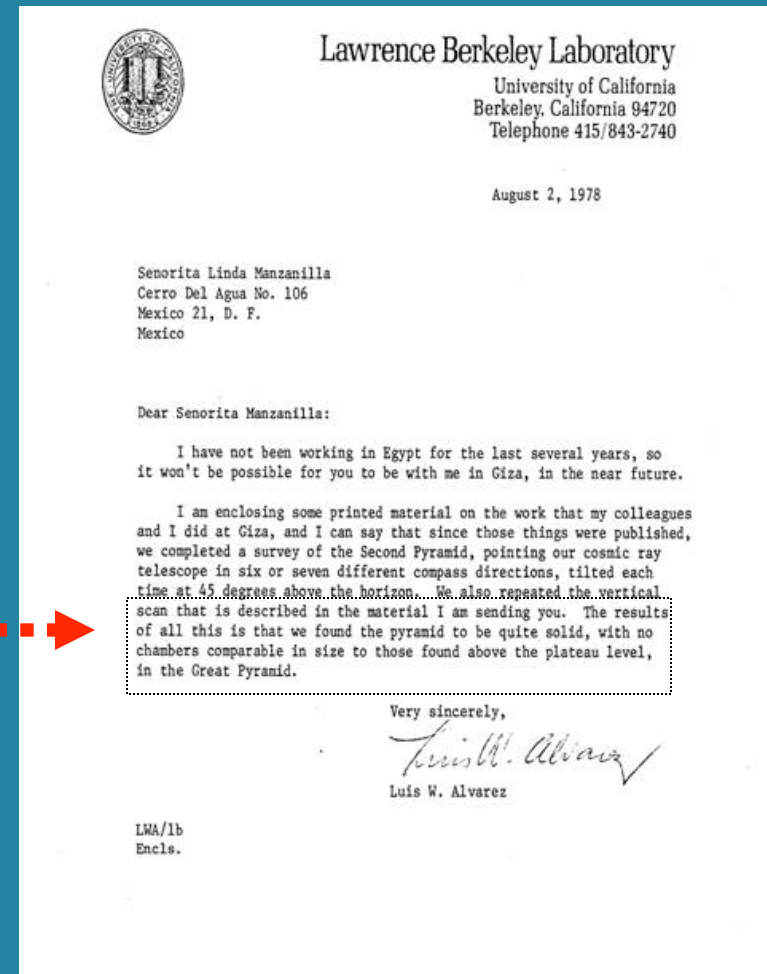
The Alvarez Experiment: Reading the trajectories of the cosmic rays

- The way in which the scientists would be able to determine the existence of a secret upper chamber, was by using the data file containing a certain number of muon events at a specific energy.
- The detector would be set at a specific energy, so that particles not passing through the chamber will likely not reach the signal, and those particles passing through the chamber would likely reach the signal.
- With complex calculations and the use of Monte Carlo simulations, the scientists can anticipate the events that take place during the experiment and graph the angles recorded by the detectors.



The Alvarez Experiment: Final results of the project

- Alvarez wrote that “the results of all this is that we found the pyramid to be quite solid, with no chambers comparable in size to those found above the plateau level, in the Great Pyramid.”



The future of cosmic rays applied in Mesoamerican pyramids



- In the case of Teotihuacan, Mexico, scientists recently installed muon detectors deep inside the Sun Pyramid, in order to track the subatomic particles that are left over when the cosmic rays hit the earth's surface.
- The magnificence of their constructions and avenues attract thousands of visitors every year, but the scientists are sure that there is much more buried under the archeological area.

Reason for experimenting with cosmic rays in Teotihuacan



- No one is still sure about who founded the city, which was the ruler, and what caused the downfall of Teotihuacan.
- The scientists expect that in the case they find a secret chamber inside the Sun Pyramid they will have understanding of this Mesoamerican culture.

The project at the archeological site of Teotihuacan, Mexico



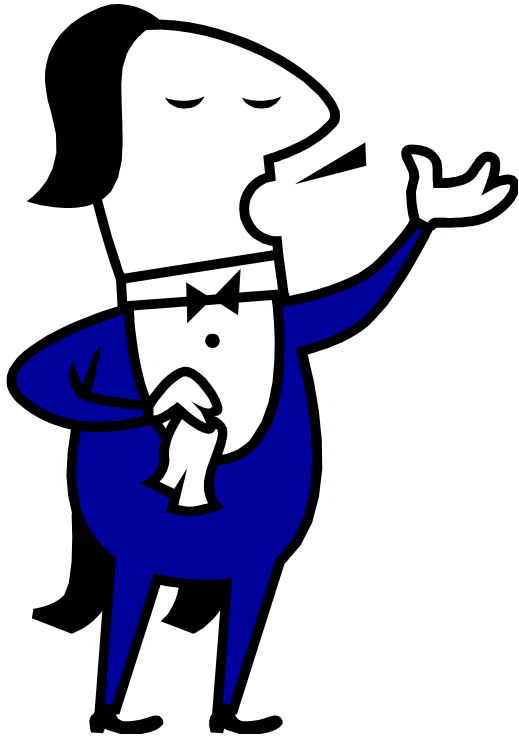
- Mexican scientists constructed at the university's laboratory a muon detector at a cost of \$500,000 dollars.
- This machine was installed inside the 63 meters high pyramid, in order to start reading the trajectories and behaviors of the cosmic rays.
- The group of Mexican scientists expects to read more than 100 million of the cosmic rays particles that are constantly bombarding the pyramid.

Conclusions



- It is evident that this technique still needs mechanical improvements, but its effectiveness seems to be trustable and well founded in correct calculations.
- If this method brings positive results in the experiments at Teotihuacan, then the way of doing archeological research will be completely revolutionized for the coming years.

Thanks for your attention!



Questions and Answers