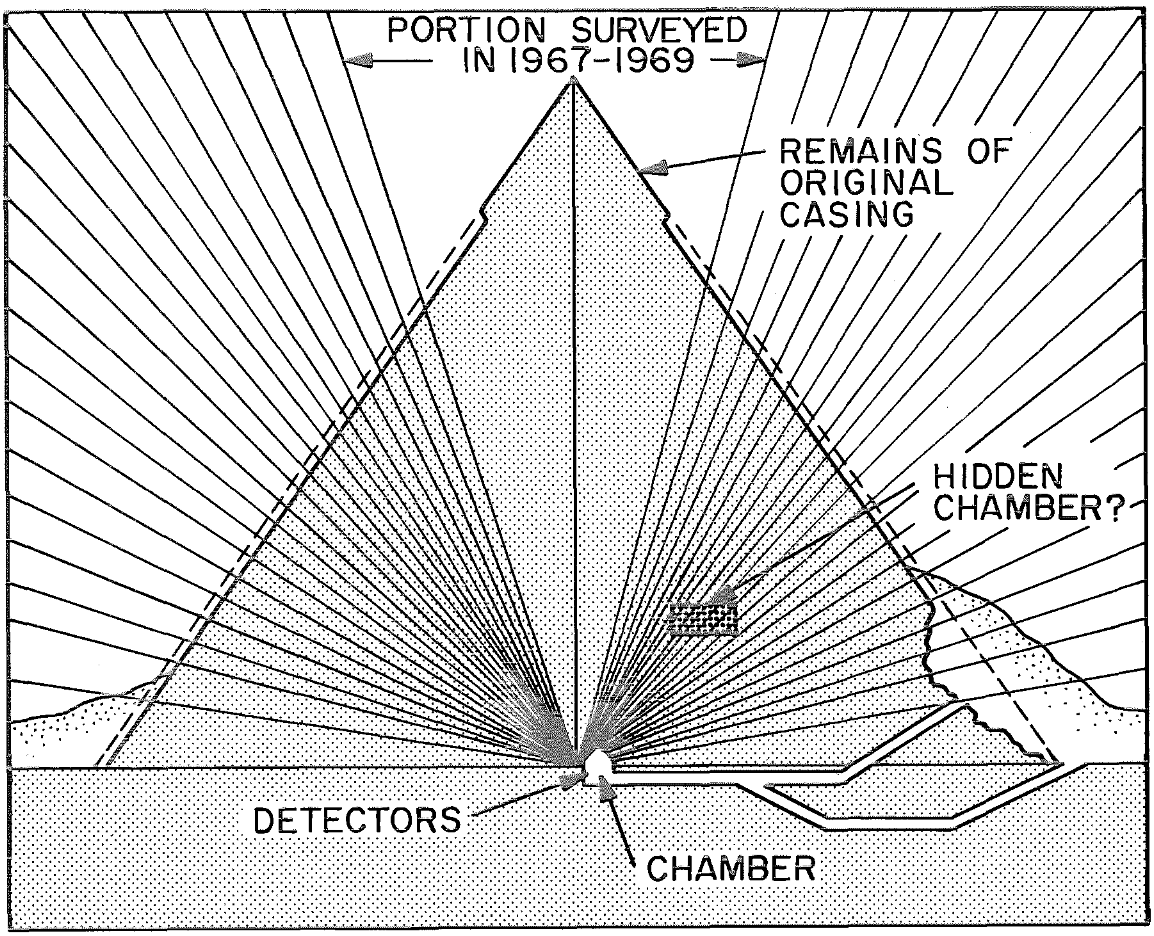
Where Were the Pharaohs Buried?

Luis Alvarez is using the cosmic radiation from space to analyze the internal structure of Khefren's pyramid.

Probing for the secrets of the pyramids has a long and somewhat checkered history. For more than 4,500 years, the rewards of the search tended to vary with the motivation of the seekers. Grave robbers plundered the pharaohs' tombs for the wealth they contained, and archeologists plumbed them for nuggets of knowledge about the nature of life in ancient Egypt. But both the seeking and the finding were fairly haphazard until, in the last few years, science—in the form of high-energy physics—entered the game. Now the odds for success seem considerably increased.

Nobel laureate Luis Alvarez, professor of physics at UC Berkeley, came to Caltech last month to give the third annual Charles C. Lauritsen Memorial Lecture at Beckman Auditorium—and explained what is happening. In



A pyramid is no small structure; Khefren's, for example, is taller than a 40-story building, covers more than 11 acres, and contains more than 2,000,000 stones weighing an average of more than 2 tons each. Even cosmic radiation has a hard time penetrating it. But the strikes that are being recorded on detectors in the one known chamber should reveal whether or not it has any hidden hollows.

"Where Were the Pharaohs Buried?—Probing the Pyramids with Cosmic Rays," he described how he and a group of Egyptian scientists are "x-raying" the second of the three great pyramids at Giza, Egypt, in the hope of finding its builder's tomb. Cosmic rays are a special interest of Alvarez, and they can be used to outline the internal structure of the pyramid in much the same way as x-rays outline the bony structure of a human being.

Pyramids are essentially huge stone mounds erected to hide the bodies and burial trappings of the ancient pharaohs. This one—458 feet high and 708 feet on a side—was built by Khefren, whose face is memorialized in the nearby Sphinx. The first pyramid in the group, built by Khefren's father, Cheops, and the third, built by his son Menkure, contain intricate mazes of blind passageways and hidden chambers—all designed to baffle grave robbers. It was a worthy but unsuccessful ploy, because these labyrinths never did more than delay the sneak-thieves in their breaking and entering.

Khefren's pyramid has only one easily accessible chamber—as far as anyone knows. It was discovered in 1818 by an Italian archeologist named Giovanni Belzoni, but he found that someone had been there before him. The lid to the empty sarcophagus was lying on the floor. Why didn't Khefren try harder to hide his burial place? Or did he? Is this chamber a decoy, and is his true sarcophagus hidden somewhere else in the pyramid? Is the apparent simplicity really duplicity? The anomaly mystifies scientists and challenges them to check it out.

Checking it out is what Alvarez has been doing at intervals since 1967. With a pair of six-foot-square spark chambers that act as detectors, and some sophisticated electronic equipment that includes a digital computer, he is using the cosmic radiation from space to analyze the internal structure of Khefren's pyramid.

The technique for the search is based on the fact that cosmic rays, which continuously bombard the earth, collide with atoms in the earth's atmosphere and create a variety of sub-atomic particles. These particles strike the earth at known energies and rates. One of them, the muon, is being used to solve the riddle of the second pyramid.

The two spark-chamber detectors are mounted one above the other in the only known room in the pyramid, and they record the number of muons that penetrate through it and the direction from which they come. It is known how many muons would strike the detectors every day if they were out in the open. But the pyramid's five million cubic yards of stone are in the way, and that amount of rock blocks a calculable number of muons from reaching the detectors. If, somewhere in the seemingly solid structure, there is a hole, more muons would come through simply because there would be no rock in that space to impede them. The detectors should show a greater number of strikes in the direction of such a hole; for example, a 15-foot hole in a 300-foot pyramid would give a 10 percent increase in intensity of muon strikes.

In surveys made in 1967 and 1969, the detectors were rigidly fixed and could scan only a cone-shaped portion directly above them around the vertical axis of the pyramid. But even that limited area proved the feasibility of the technique because the portion surveyed includes the small remaining section of the pyramid's original limestone casing, and the detectors accurately recorded the additional thickness. (They also identified precisely how far off center the detection chamber is.) Now the detectors have been remounted so that they can be "pointed" in any direction and the whole pyramid can be surveyed. To date they have been pointed consecutively at the western and southern faces and the northeast corner of the pyramid, and they are currently trained on its southwest corner.

The strikes recorded by the detectors are stored on magnetic tape and returned to Berkeley for computer analysis. The latest tape, with more than 400,000 muon strikes on it, is now being processed. And a computerized image of the strikes shows an area about halfway up one side of the pyramid that appears to be a little darker than the surrounding areas.

Does this indicate a hidden chamber? Perhaps. But the strikes have to be sorted out by a kind of analysis of statistical fluctuations before anyone can really tell. As in flipping a coin, in 100 flips the coin is likely to come up heads 50 times and tails 50 times—or at least not vary more than 60-40. But if something about it weights the probability of one side or the other turning up more often, it will have to be flipped many times more than 100 to prove that the effect is real and not random. In the same way the data from the muon detectors at Giza must be "flipped" many thousands of times until the statistical fluctuations are quite small compared to the effect being sought. If that happens, the scientists will be fairly sure of the existence of a hidden chamber. Of course, the smaller the chamber, the longer it will take to find it—but no matter how small, if it is there, eventually it will show up.

If the cosmic-ray search does reveal a hidden room, Alvarez will have made the greatest archeological find since King Tut's tomb was discovered in 1922. But if Khefren's pyramid turns out to be as straightforward as it seems, that too will be an answer, and high-energy physics will have provided archeology with a reliable tool for the age-old game of treasure hunting.