*Luis Alvarez*

*Berkeley pioneer and 1968 Nobel laureate Luis Alvarez, who developed Donald Glaser's bubble chamber idea into a versatile physics tool, died on 1 September, aged 77.*

# Luis Alvarez

## Nobel Prize for Physics

The 1968 Nobel Prize for Physics was awarded to Luis Alvarez of the Lawrence Radiation Laboratory, Berkeley, USA, for his 'decisive contributions to particle physics, in particular, the discovery of a large number of resonance states made possible through his development of the technique of using hydrogen bubble chamber and data analysis'.

Alvarez has applied himself in a variety of fields during his life in physics ; in practically all of them he has achieved some outstanding work. He was born in San Francisco on 13 June 1911, the son of a distinguished medical man. It was in his father's laboratory that he learned to use his hands on electrical and mechanical apparatus, eventually spending two summers as an apprentice in a scientific instrument maker's machine shop. This stood him in good stead in later years when he needed to convert ideas into practical apparatus, and in University years he could get things done 'when the professional machinists were all working for the full professors'.

The University was that of Chicago where he took all his degrees through to Ph. D. in 1936. He was initially aiming for a degree in chemistry but 'seven straight Bs' in his chemistry courses helped to convert him to physics. This was immediately after A.A. Michelson's era at Chicago and he was therefore greatly influenced by things optical.

As a graduate student he built some of the first new fangled Geiger-Muller counters which in turn led to his first major scientific work. Prompted by A. Compton, he took his counter to the roof of Geneve Hotel in Mexico City and, at the same time as T. Johnson, looked at the cosmic ray intensity to the East and to the West. By proving that more cosmic rays came from the West, they showed that, given the effect of the earth's magnetic field, the incoming cosmic rays were positively charged.

From Chicago, Alvarez joined E.O. Lawrence's team at Berkeley and moved in time from Instructor in Physics (1938), to Assistant Professor (1939), to Associate Professor (1941) and to full Professor (1946). Those early years under Lawrence, through to the war, were very fertile. He demonstrated K-electron capture in nuclei; developed a method of producing slow neutron beams and of neutron time of flight measurement and achieved the first acceleration of heavy ions in a cyclotron. Together with J. Wiens he made the first mercury 198 lamp and showed that its pure spectral line structure made it an ideal standard of length. This mastery of equipment led to several important experiments. Using his slow neutrons he investigated, with K. Pitzer, the scattering of neutrons in ortho and para hydrogen and, with F. Bloch, measured the magnetic moment of the neutron.

Another major discovery, in 1939 with R. Cornog, concerned tritium (hydrogen 3) and helium 3. A team in the UK under Rutherford had evidence of these isotopes and the arguments suggested that tritium was stable and helium 3 radioactive. Alvarez calculated that he could make enough of them by bombarding deuterium with the LRL 37 inch cyclotron to detect them as accelerated ions using his new technique on the 60 inch cyclotron.

While testing the background on the 60 inch cyclotron, with ordinary helium in the ion source, before using the activated deuterium, a very astute observation and interpretation showed them that helium 3 is a stable constituent of helium. Immediately afterwards, they showed that tritium is radioactive.

The war years took Alvarez to MIT to follow up the great technical achievements of the UK physicists in the use of radar. His inheritence from Michelson here proved invaluable, playing a part in three successes that marked his intrusion into radar. The first was the development of GCA (Ground Controlled Approach), the 'blind-landing' system for guiding planes down. It involved the construction of arrays of radar antenna acting like one of Michelson's diffraction gratings.

Similar arrays were built into the large wings of B-29 bombers for Alvarez's second radar achievement known as Eagle. This enabled radar maps to be taken in all weathers and allowed high altitude blind bombing. The third achievement was the MEW, microwave early warning system, which proved an extremely useful and versatile device.

From 1943 to 1945, he joined the team engaged on the atomic bomb project under R. Oppenheimer at Los Alamos. Again he had to turn his hand to something different — this time the development of the implosion method for setting off bombs, in contrast to the more conventional gun-assembly method. The implosion method was the detonator of the first plutonium bomb.

While at Los Alamos, he conceived a new type of linear accelerator using techniques he had mastered during his radar days. The structure is known as the 'Alvarez-structure' and has been used in linear accelerators throughout the world (for example, in the 50 MeV linear injector of the CERN proton synchrotron). Alvarez and his colleagues built the first 32 MeV linac using the new structure within two years.

After the war, Alvarez realized that he had been away from the rapidly developing field of particle physics for too long. He had to decide, on returning to Berkeley, whether to retire into a scientific administrator's office with his press cuttings or to start learning again. He settled for the latter and took on two first class graduate students, L. Stevenson and F. Crawford, as research assistants on condition that he would in fact be their research assistant. This radical approach brought him back into the front line within a few years.

In 1952 came D. Glaser's brilliant invention of the bubble chamber and Alvarez was one of the first to realize its enormous potential. Glaser had used xenon in a tiny chamber to show what could be done. Alvarez began developing the same year a liquid hydrogen chamber, building in sequence a 4 inch, a 10 inch, a 15 inch and then a 72 inch chamber. The 72 inch (with a cross-section of 20 x 15 inches in a field of 15 kG) was regarded as an almost impossible monster when it was first proposed. Lawrence told Alvarez 'I don't believe in a big chamber at this time, but I do believe in you'. His faith was rewarded for in 1959 Alvarez and his colleagues brought the chamber into operation and it began physics in the Spring of 1960. Within the next two years it contributed results which marked a turning point in the development of particle physics.

This turning point concerned the discovery of resonances. One mysterious resonance had been found on the Chicago 450 MeV synchro-cyclotron in 1952 but it was the Alvarez group which showed that resonances are a general phenomena of particle physics. With the 72 inch chamber fed by the 6.2 GeV Bevatron, they found the first strange particle resonance $Y^*_1$ (1385) and the first boson resonance $K^*$ (893) and many others, so that they still have to their credit a very high proportion of the resonances so far identified.

In parallel with this bubble chamber work, Alvarez realized that new techniques would be needed to handle the huge volume of information that they could produce. As early as 1955 he tabled the basic parameters for semi-automatic measuring machines. Such machines were constructed and perfected, beginning with the 'Franckenstein' and now with the 'Spiral Reader'. Computer programs and techniques for the analysis of the output of these machines were also developed, particularly with the help of F. Solmitz.

Alvarez is currently leading two exotic projects. One is to X-ray the pyramids of Egypt using a spark chamber array to look at the cosmic ray muon flux. The purpose is to locate any hidden cavities in the pyramid structure which could be the sealed tombs of the Pharaohs. The second is HAPPE (High Altitude Particle Physics Experiment). Spark chambers with a superconducting Helmholtz coil to give complete magnetic analysis of events will be sent up in balloons to study the interaction of ultra-high energy cosmic rays (1000 GeV range) with particles in the upper atmosphere.

It is this life of achievement that has been recognized with the award of the Nobel Prize.