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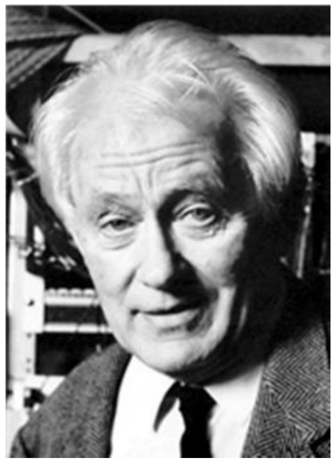
Nobel Prize in Physics 1992



Georges Charpak

The Nobel Prize in Physics 1992 was awarded to Georges Charpak *"for his invention and development of particle detectors, in particular the multiwire proportional chamber"*.

Information about winners:

Georges Charpak,

France, École Supérieure de Physique et Chimie, Paris and CERN, Geneva, Switzerland

RESEARCH INFORMATION:

A breakthrough in the technique for exploring the innermost parts of matter

This year's Nobel Prize in physics is awarded to Georges Charpak, France, for his invention and development of detectors in high energy physics. Since 1959 Charpak is working at CERN, the European laboratory for particle physics situated in the canton of Geneva in Switzerland. Charpak invented the multiwire proportional chamber at CERN. The pioneering work was published in 1968. Largely due to his work particle physicists have been able to focus their interest on very rare particle interactions, which often reveal the secrets of the inner parts of matter. Sometimes only one particle interaction in a billion is the one searched for. The experimental difficulty lies in choosing the very few but exceptionally interesting particle interactions out of the many observed. Photographic methods, once so very successful in exploring particle processes, are not good enough for this. In the new wire chamber Charpak used modern electronics and realised the importance of connecting the detector directly to a computer. The invention made it possible to increase the data collection speed with a factor of a thousand compared to previous methods for registering charged particle trajectories. At the same time the high spatial resolution was very often considerably improved. His fundamental idea has since been developed and for more than two decades Charpak has been at the forefront of this development.

The development of detectors very often goes hand in hand with progress in fundamental research. Various types of particle detectors based on Charpak's original invention have been of decisive importance for many discoveries particle physics during the last two decades. Several of these have been awarded the Nobel Prize in physics. Charpak has actively contributed to the use of is new type of detector in various applications in for example medicine and biology.

Background information

The study of reactions between elementary particles provides knowledge of their properties and of the forces that act between them. The reactions are often very complex, sometimes several hundred particles can be created in a single reaction and to interpret them the scientists very often need to register every single particle trajectory. Up to about 1970 this registration was often done with photographic methods. The pictures were analysed with the help of special measuring devices, a slow and laborious process.

Charpak's invention consists of using an earlier development, the proportional counter, in a particularly unconventional way. The classical proportional counter, like the Geiger Müller tube, consists of a thin wire in the middle of a tube with a diameter of about a centimetre. Between the wire and the wall of the tube a high voltage of a few kilovolts is applied. A charged particle passing through the gas-filled tube will ionise the gas. In this process electrons, which have negative electric charge, are liberated from the neutral atoms of the gas, which then become positively charged. In the electric field the electrons

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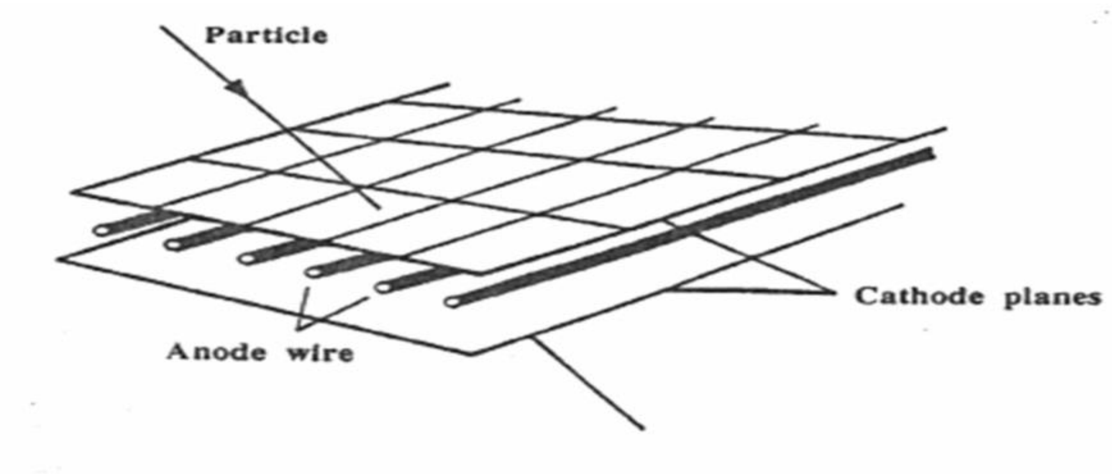
move towards the central wire, the anode. Near the wire the electric field is very strong and results in a rapid acceleration of the electrons. They then have enough energy to ionise the gas and more electrons are liberated, which in their turn are accelerated and so on. This results in an avalanche of electrons and positive ions and it is the movement of the electrons and the ions that gives rise to an electric signal on the wire. The position of the charged particle that started the ionisation in the gas can however only be determined with a precision of about a centimetre, the size of the tube.



The principle of the multiwire proportional chamber. The distance between the anode wires is about 2 mm and the distance between the cathode planes is about 2 cm. A charged particle ionises the gas between the cathode planes and the charges - the electrons and ions - move towards the anode and the cathodes respectively. Several chambers are placed at different distances from each other to make it possible to determine the particle trajectory precisely.

To cover large surfaces with layers of these classical proportional tubes is impractical and the desired spatial precision cannot be reached. The break-through occurred with Charpak's invention of the multiwire proportional chamber. It consists of a large number of thin, parallel wires arranged in a plane between two cathode planes a few centimetres away. The thin anode wires have a diameter of about a tenth of a millimetre and are placed about one or a few millimetres apart. In 1968 Charpak, contrary to the

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general belief, realised that each wire would behave as a proportional counter and result in a spatial precision of about a millimetre or less. Each wire could stand a very high rate of particles, several hundred thousand per second, at that time an exceptionally high rate.

Each wire has an amplifier. The use of such a large number of amplifiers is feasible thanks to the developments in electronics which make it possible to construct compact amplifiers with very small power requirements. An additional very important advantage is the ability to register the signals with computers and handle large amounts of data.

In this pioneering work from 1968 Charpak also points to possible developments of the multiwire proportional chamber. One such application makes use of the time it takes for the primary ionisation to drift to the anode wire. A measurement of the drift time results in an improved spatial precision. This application is called a drift chamber and a spatial resolution better than a tenth of a millimetre has been obtained.

History

Very often discoveries in physics are related to detector development. For the development of the cloud chamber, which registers tracks of charged particles in a gas, the 1927 Nobel Prize was awarded to C.T.R. Wilson. The cloud chamber was used in the discovery of the first antiparticle, the positron, for which C.D. Anderson (of Swedish descent) was awarded the 1936 Nobel Prize. The 1948 Nobel Prize in physics went to P.M.S. Blackett for his development of the cloud chamber technique and its use in the study of the atom nucleus and the cosmic radiation. In studies of the cosmic radiation during the 1940's and 1950's special photographic emulsions were used to register the tracks of charged particles. C.F. Powell was awarded the 1950 Nobel Prize in physics for the development of the emulsion technique and the discovery of the pi meson.

The invention of the bubble chamber, for which D.A. Glaser received the 1960 Nobel Prize in physics, was of great importance for the evolution of particle physics in the 1960's. In the bubble chamber, which is filled with an overheated liquid, charged particles give rise to small bubbles where the liquid is boiling along the track. These strings of bubbles are photographed. However, pictures can only be taken about once per second. During the

1960's a large number of new elementary particles were discovered thanks to the bubble chamber technique and L.W. Alvarez was awarded the 1968 Nobel Prize in physics for the development of this technique.

Charpak's discovery in 1968 started a massive development of different types of wire chambers. Today practically every experiment in particle physics uses some type of track detector that has been developed from Charpak's original invention. Charpak himself has been in the centre of this development from which thousands of scientists, both at CERN and elsewhere, have profited. When the charm quark was discovered in 1974, resulting in the award of the 1976 Nobel Prize in physics to B. Richter and S.C.C. Ting, several multiwire proportional chambers were used. The wire chamber was also used in the discovery of the intermediate bosons at CERN in 1983. For this discovery the 1984 Nobel Prize in physics was awarded to C. Rubbia and S. Van der Meer. Detectors developed by Charpak are being used more and more outside physics, e.g. in medicine for the detection of X-rays.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1992/press.html