BUBBLE CHAMBER

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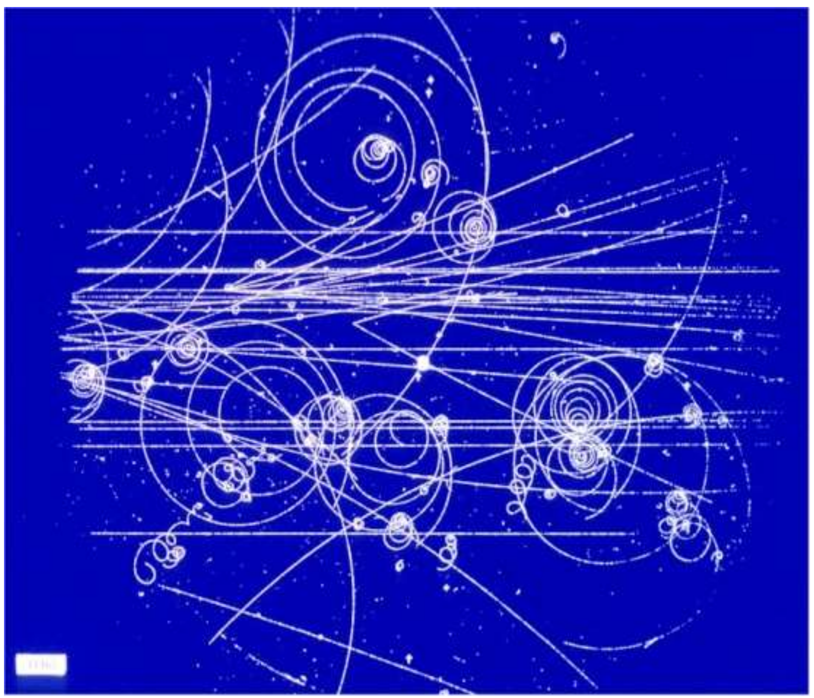
BUBBLE CHAMBER

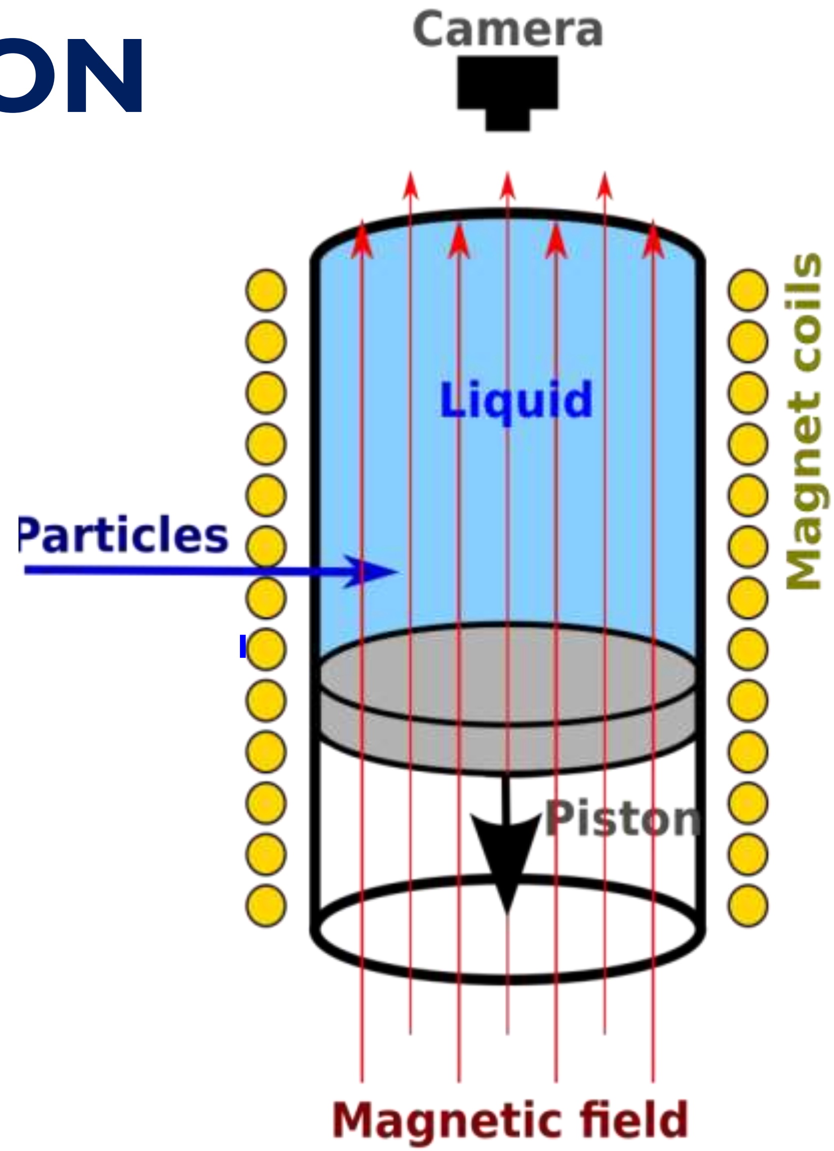
A bubble chamber is an instrument designed to detect charged particles through the tracks of bubbles present in a chamber consisting of a superheated liquid (such as liquid hydrogen) that boils into tiny bubbles of vapour around the ions produced along the tracks of subatomic particles.

It was invented by American physicist Donald A. Glaser in 1952.

CONSTRUCTION



Example of
crowded picture



WORKING PRINCIPLE

- It consists of a pressure-tight vessel containing liquid (often liquid hydrogen) that is maintained under high pressure but below its boiling point at that pressure.

- Few milliseconds before the arrival of the beam particles (fast ejection), the pressure on the liquid is suddenly reduced by expanding the volume by about 1% by means of a piston, the liquid becomes superheated; in other words, the liquid is above its normal boiling point at the reduced pressure.

- As charged particles travel through the liquid, the energy deposited initiates boiling along the path, leaving a trail of tiny bubbles along the particle tracks.

- By photographing the bubble trails it is possible to record the particle tracks, and the photographs can be analyzed to make precision measurements of the processes caused by the high-speed particles.

- Multiple cameras are mounted in the chamber to provide a three-dimensional record of the event.

- Once the photographs are taken, the bubbles collapse upon recompressing the liquid. The bubble chamber is now ready for the next burst of particles. New collisions can be recorded every few seconds when the chamber is exposed to bursts of high-speed particles from particle accelerators.

Due to the constant application of a magnetic field, the charged particles travel along a curved path. The degree of curvature is dependent on the charge, speed, and mass of the particle.

Calculation of momentum and energy

Magnetic force due to magnetic field act as

$$F= q(V \times B)$$

$$F= qVB\sin\theta$$

as force is perpendicular to the direction of motion i.e. the angle between V and B is 90^0

so $$F=qVB$$

this magnetic field ,force to move the radiations in circular path which is centripetal force given as

$$F=mV^2/r$$

so by comparing both equations

$$qVB=mV^2/r$$

$$\text{or } mV=P=qBr$$

from momentum we can also find energy of the particle

as $$P^2=2mE$$

$$E=P^2/2m$$

BENEFITS

The key benefits of a bubble chamber include:

- It provides real three-dimensional images at a good spatial precision of 10 μm to 150 μm.
- It can be subjected to a magnetic field for accurate detection of momentum.
- The number of interactions inside the bubble chamber can be increased by a higher density of a liquid.

- The bubble chamber is no longer in wide use but the photographs that these machines produced are excellent for 'seeing' particles and the way that they behave. Therefore they form an excellent teaching tool, and use ideas which is easy to understand.

- The great advantage is their ability to pick up details of a complicated interaction, and by following the trails of bubbles one can see subsequent interactions and decays of the products of the initial interaction.

- Furthermore the principles by which the pictures are made and analyzed are easily understood.

DRAWBACKS

Some of the major drawbacks of a bubble chamber

- Compared to newer techniques, it is quite slow process maybe a few seconds to operate due to the need for event reconstruction and film measurement. so the number of pictures is limited and the analysis of them is labor intensive. . Modern detectors allow many thousands of events per second, and the images are computer generated.

- The liquid within the chamber serves as both a target and detector, hence bubble chambers cannot be used with modern colliding-beam machines.

APPLICATIONS

- The bubble chamber is useful for analyzing high-energy particles.

- It is also used for measuring precisely decays with extremely short lifetimes