A timely way to track particles

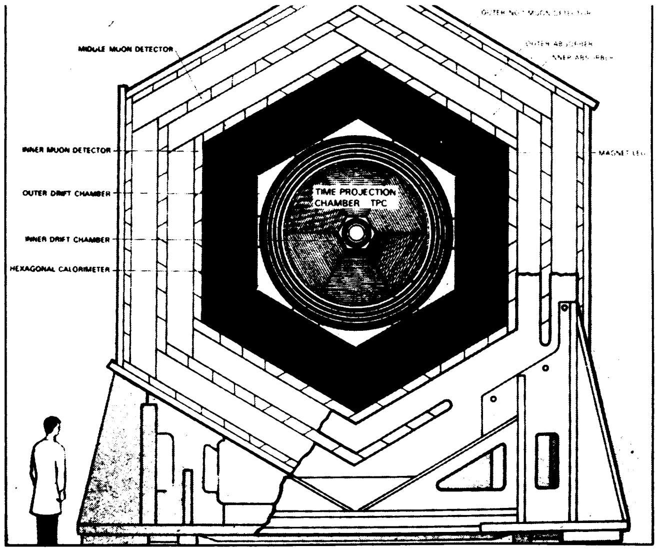
To detect and identify subatomic particles and to measure their properties physicists have used a wide variety of apparatus. As physics has progressed and become more sophisticated, the devices have changed. The Wilson cloud chamber and the Geiger-Müller counter were well suited technically to the leisurely world of cosmic rays and natural radioactivity, when they were invented almost 100 years ago, and they are still used in those fields. The latest bubble chambers and streamer chambers are meant for artificially induced reactions, which come at high energies and high repetition rates in the biggest modern accelerators.

Now there is a detector designed specifically for the collisions and annihilations of matter and antimatter in the storage ring and colliding-beam facilities now so popular among physicists. It is called the Time Projection Chamber (TPC). David A. Shirley, director of the Lawrence Berkeley Laboratory in Berkeley, Calif., where the TPC was invented, calls it the "most advanced and most sophisticated particle detector . . . a doorway to the future in high energy physics . . . a transition from the era when the accelerator was dominant to the era of colliding beams."

Shirley was speaking specifically of the first large-scale application of the principle, which has been built over the last five years at the PEP colliding-beam facility of the Stanford Linear Accelerator Center in Palo Alto, Calif. This apparatus is ready to begin experimentation, and it was "unveiled" late in January in conjunction with the American Physical Society meeting in San Francisco.

The TPC is designed for the characteristics of the collisions and annihilations that occur in colliding beams. It can measure simultaneously in three dimensions the tracks of the large number of particles emanating simultaneously in all directions from the collision point, and it can also discriminate one kind of particle from another. It is claimed to be the only device that can do both of those determinations and do them fast.

The tracks are ionization tracks. An electrically charged particle moving through some matter — in the TPC it's a mixture of argon and methane—will leave a wake of ionized atoms behind. This track lasts for a short instant before it recombines. The TPC is designed so that the collision point, where all the tracks begin, is in its center. It is simply a six-meter-long cylinder surrounding that point. An electric field is generated by an electrode at the center of the cylinder biased to 100,000 volts negative. In this field the electrons detached from the atoms in the track move to the ends of the cylinder. The field is so uniform that they move with the same velocity, and so preserve their sequence. A magnetic field also present gives a rigidity to their motion that aids this preservation. The arrival of the electrons at the ends of the chamber is recorded by an array of wires. The device compares the time of arrival of each electron with the time of the original matter-antimatter collision and can thus determine the depth from which it came. A spatial measurement is thus gained by projecting time. The two dimensions transverse to the axis of the cylinder are determined by which wire was struck and where it was struck. The signal produced by the striking is proportional to the depth of ionization along the track, and the ionization depth will identify whether the particle that made the track was an electron, pion, kaon, muon, proton or maybe even a quark.



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End view of TPC. The calorimeters record electrically neutral particles, which the TPC does not. TPC does not distinguish muons well, hence auxiliary muon detectors.

David Nygren of the Lawrence Berkeley Laboratory, inventor of the TPC, says that he got the idea in "a flash of inspiration" in 1974. He made a model the size of a Coca Cola bottle. Now it has been scaled up to six meters. Meanwhile, more than 1,000 requests for copies of his original paper on the subject have been received. Large TPC's are being planned for the projected LEP colliding beams at the CERN laboratory in Geneva and for the Japanese installation TRISTAN in Tsukuba. Two small versions have actually been operated at the Fermi National Accelerator Laboratory in Batavia, Ill., and at the TRIUMF cyclotron in Vancouver, B.C. —*D.E. Thomsen*

Guaymas Basin: Oil and microbial mats

The old adage "expect the unexpected" seems tailored for scientists studying vent systems at spreading centers on the ocean floor. Exploration of the Guaymas Basin in the Gulf of California has led to the discovery of the first known petroleum formations at deep-sea vents. Researchers report in the Jan. 21 NATURE that hydrocarbons form when a thick layer of organic sediments comes into contact with hot basalt at the vent spreading center.

In a recent return visit to the site, scientists were further surprised to find that what they had previously assumed to be a layer of mineralized precipitate covering the petroleum-containing mounds were actually mats of fluffy, white microbes — the first such mats discovered at deep-sea vents.

Vents in the Guaymas Basin, while similar in many ways to other known vent systems, allow scientists their first chance to observe the ongoing processes involved in the formation of both petroleum and ores. The petroleum is "noncommercial," scientists caution, but it may lead geologists to a better understanding of the temperatures, time and pressure needed to form oil in other settings.

Unlike known vents outside the Gulf of California, which have little or no sedimentary cover, skeletal debris from microscopic algae rain onto the seafloor in the Guaymas Basin at a rapid clip of about a meter per thousand years. The sedimentary layer, from 100 to 500 meters thick, probably began forming 500,000 to two million years ago when the rift in the basin began to spread, said Berndt Simoneit of Oregon State University. Simoneit and Peter Lonsdale of Scripps Institution of Oceanography first obtained the oil during a cruise in 1980.

Vent petroleum forms much faster than that formed in the deep crust according to the classic geothermal recipe. Simoneit says the process begins as organic carbon at the bottom of the sedimentary blanket and closest to the hot basaltic bottom layer starts to cook. Oil-like material is generated. As superheated water moves along the fault it carries oil, hydrogen sulfide and trace elements, and spurts through the vents at temperatures as high as 300°C. The petroleum is found percolating up through the sediments and in globules congealed into ore mounds 20 to 30 meters tall.

Biologists are exploring the possibility that some bacteria at the Guaymas vents metabolize hydrocarbons in the way that bacteria at other vents use hydrogen sulfide, providing an energy source for the food chains. —*C. Simon*