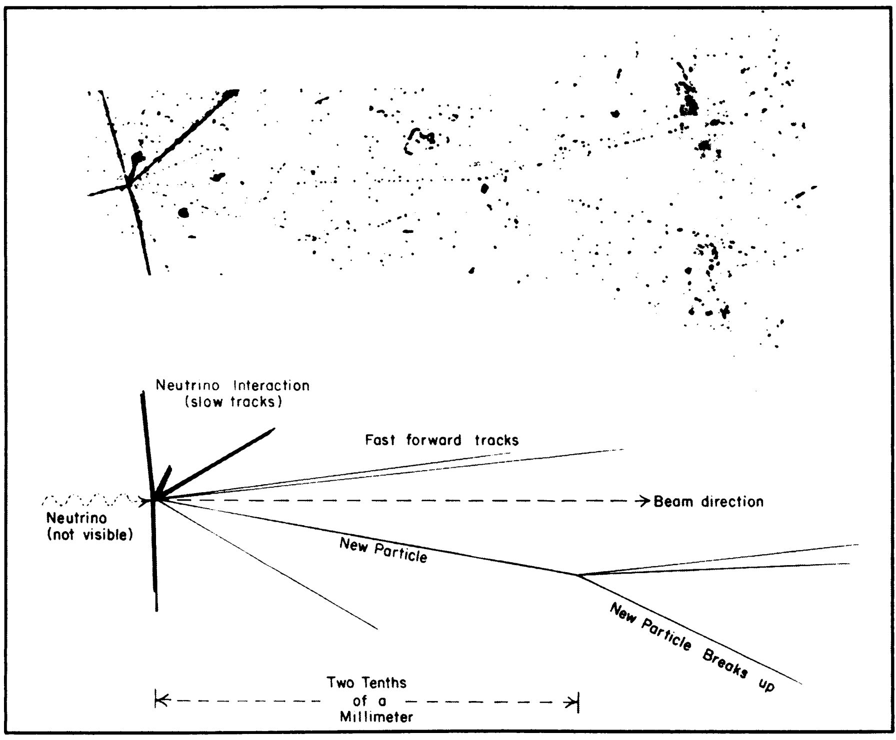
Catching a psi particle in its tracks



First recorded track of a charmed particle follows neutrino interaction in emulsion.

Fermilab

The second anniversary of the discovery of the first of the psi particles, the family of ultraheavy particles possessing the new characteristic that physicists have called charm, has recently passed. In those two years enough evidence has piled up for the existence of this new group of particles to convince the Nobel Prize committee to award the 1976 physics prize to two of the discoverers of the first one.

But up to now, all that evidence, however convincing, has been rather indirect. Belief in the existence of the psi particles has been based on the testimony of their decay products. The psi's, which are produced nowadays in a multitude of different ways, exist for an extremely short time before decaying into other particles. The properties of the psi's have been deduced from the nature and behavior of these decay products.

What had been lacking was a direct picture, so to speak, the actual track of a psi particle. Now that is supplied.

The track was obtained by a collaboration of physicists from seven countries led by E. H. S. Burhop of University College, London, one of the world's most renowned particle physicists. The instrument used was the world's most powerful particle accelerator located at the Fermi National Accelerator Laboratory near Batavia, Ill. Participants came from Fermilab; the Inter-University Institute for High Energies at Brussels; University College, Dublin; the CERN Laboratory at Geneva; Imperial College, London; the Institut des Sciences Exactes et Appliquées in Mulhouse, France, the University of Rome and the Université Louis Pasteur at Strasbourg.

The reason the actual track of a psi particle escaped detection for so long has to do with the shortness of their lifetimes (on the order of a few times 10^{-13} seconds) and the nature of the detectors used in previous experiments. Either the charmed particle did not live long enough to enter the detectors, or, if it was created within them, it did not last long enough to make an impression. The detectors in question do not record the track of a particle as a continuous line, but as a series of dots (usually made by spark flashes) through which a line can be drawn. The lifetimes of the psi particles are so short that they tend to fall between the dots.

To detect a psi track Burhop and his collaborators used a block of nuclear emulsion. This is a more sensitive (and three-dimensional) version of the coating familiar on photographic film. Many particles besides light will make the same sort of dark impression in the emulsion. Tracking in an emulsion is a follow-the-dots procedure too (it depends on the particle's impressions on individual atoms), but the dots are much closer together.

Still, the lifetime of a psi particle is so short that even if one could be created in the emulsion, finding its track among the myriads of other tracks in the emulsion (from other particles in the same experiment, background radiation, cosmic rays, etc.) was a formidable task. The emulsion was surrounded by an array of other detectors to record the decay products of a possible charmed particle and give the scanners a direction fix on the part of the emulsion to examine. In the end, a track 0.2 millimeters in length was found, which, from the surrounding circumstances, the physicists believe is that of a charmed particle. Which particular one it is has not been determined. The formal report will appear in a forthcoming issue of PHYSICS LETTERS. ☐

Doubt over discovery of element 126

Great excitement was caused in the worlds of physics and chemistry last summer by the announcement that evidence for the existence of element 126 had been found in certain inclusions in samples of the mineral monazite that came from ancient deposits in Africa (SN: 6/26/76, p. 404). The splash sent ripples through nuclear physics, chemistry and even weapons technology. The existence of element 126 in such old minerals (as well as other superheavy elements for which evidence was alleged) would mean that these nuclei were much stabler than physical theory had suggested. Answering the question whether such nuclei are fissionable under the impact of thermal neutrons could tell whether it might someday be possible to make bombs with far less fuel than current nuclear bombs require.

Since the original report, by Robert V. Gentry of Oak Ridge National Laboratory and six others, scientists in various countries have been examining monazite samples looking for evidence of element 126 to confirm or refute the finding. According to Albert Ghiorso of the Lawrence Berkeley Laboratory, who recently gave a talk that included a summary of the current state of the affair 126, conclusions of other parties are increasingly negative, and there is a growing skepticism that element 126 does, in fact, exist in these ancient monazite samples. "It would be very startling if the discovery was confirmed," Ghiorso told SCIENCE NEWS.

Ghiorso did not do any of the element-126 experiments himself, but he has been involved in the discovery of numerous other transuranic elements and is regarded as a foremost expert on superheavy nuclei. He says he was skeptical of the element 126 claim from the beginning and he was not surprised when a meeting of interested scientists held at Caen, France, during the past summer came to a generally negative conclusion.

The claim is based on an examination of what are called giant haloes in the monazite samples. These haloes are apparently due to radiation damage, and the giant ones seemed likely to be due to damage by very heavy radioactive nuclei. The experiment Gentry and his collaborators did at Florida State University in Tallahassee irradiated the giant haloes with protons in an attempt to identify the elements there. The protons should energize the elements, and the elements should then identify themselves by emitting characteristic X-ray spectra. (The emission spectrum for any atom, known or hypothetical, can be calculated from well-tested principles of atomic physics.)

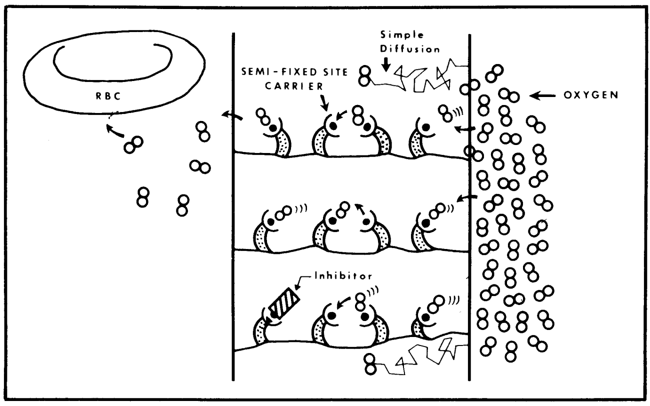
Among other things, Gentry and his group found a characteristic X-ray emission that could have come from element 126. They published a paper setting forth that interpretation. The attitude taken by subsequent investigators is perhaps epitomized in a paper by a German group, F. Bosch of the Max Planck Institute for Nuclear Research in Heidelberg and seven others in the Nov. 29 PHYSICAL REVIEW LETTERS. Bosch and collaborators point out quite briefly that they have examined monazite samples for evidence of element 126 and found none. They and others explain the X-ray emission that Gentry and his group attributed to element 126 by saying that the protons that irradiated Gentry's samples probably encountered cerium nuclei that happened to be in the mineral and turned the cerium into praeseodymium. That element then decayed, emitting a neutron and the same X-ray wavelength as element 126 would have as it went.

Gentry acknowledges the growing skepticism but points out that the critics have not done exactly the same experiment as he and his collaborators did: They have not irradiated the giant haloes specifically but dealt with monazite at large. Gentry told SCIENCE NEWS he is now engaged in a series of experiments which he hopes will settle the question one way or the other. He says he has no particular emotional investment in the way it goes. He would like the result to be favorable, but what he most wants to do is end the uncertainty.

Gentry's new experiments are being done at the Stanford Linear Accelerator Center in California. They consist of irradiating the giant haloes with X-rays produced as synchrotron radiation by the accelerated electrons there. X-ray irradiation should also energize whatever elements are in the haloes and induce them to emit their own characteristic X-rays, but it is a more sensitive method and improves on the previous method in two ways.

For X-ray absorption each element has a calculable threshold above which it will absorb energy and radiate its own characteristic spectrum, but below which it will not. "If we radiate above the threshold for 126 and see emission, and then irradiate below the threshold and don't see any" that will be pretty good evidence, he says. Furthermore, irradiation with X-rays removes the possibility of proton-induced formation of praeseodymium to confuse the emitted X-ray spectrum. The first runs, made during the summer were inconclusive because of interference and other problems, but Gentry is on the point of returning to Stanford for more runs, which he hopes will be free of problems. He expects to have a definitive answer by the end of December. ☐

Oxygen's boost across the placenta



Burns and Gurtner

Example of a hypothetical carrier (center) that assists oxygen molecules (right) in their passage through the placenta to the fetal circulation (left).

For many years physiologists thought that oxygen traveled from the maternal bloodstream to the fetus only by passive diffusion—the random movement of molecules from regions of high concentration to regions of low concentration. Now this long-held, widespread belief has been squelched by two Johns Hopkins University physiologists—Barry Burns and Gail Gurtner.

They have found that oxygen gets ferried across the placenta faster than other gases do—apparently courtesy of some molecular carrier. They have also found that certain chemicals interfere with this facilitated oxygen transport, and such interference may explain how these chemicals can lead to miscarriages, birth defects and underweight newborns.

In the past, physiologists had no means of determining whether oxygen moves passively or actively through the placenta. Burns and Gurtner overcame this problem by devising an elaborate placental perfusion system where they could compare the rate of passage of oxygen through the sheep placenta to the rate of passage of other inert gases like argon and helium. They found, when they artificially perfused the placenta, that oxygen moved through the placenta faster than the other gases did, indicating that oxygen was somehow assisted in its movement through the placenta.

But if oxygen gets through the placenta more rapidly than other gases, how does it do so? Might a particular molecule be helping it? Burns and Gurtner suspected that a particular drug-metabolizing enzyme known as cytochrome P-450 might be responsible since it is present in the placenta and is known to latch onto oxygen molecules while in the process of metabolizing drugs. They tested this hypothesis by adding a drug known to inhibit cytochrome P-450 to their placenta perfusion system. The drug did indeed inhibit oxygen transfer through the sheep placenta but did not affect transfer of inert gases, strongly suggesting that cytochrome P-450 is the oxygen carrier.

However, more experiments must be conducted to really prove this, and obtaining such proof will be difficult since the enzyme has been only partially isolated from the endoplasmic reticulum—that area of the cell in which it resides. Another chemical might actually be the carrier. But probably some carrier is responsible, Burns says, since the placenta is 100 to 500 times thicker than the tissue interface between blood and air in the lungs and thus presents a lot of resistance to the passage of gases.

Subsequent experiments then showed them that certain drugs, notably anesthetic gases and carbon monoxide from cigarette smoke, dramatically reduce oxygen transport through the sheep placenta. These findings underscore the well-known danger of smoking and drug use to human pregnancy and also shed light on how cigarettes and drugs might exert their damage. Carbon monoxide, for example, binds with the oxygen carrier molecule so that oxygen does not get through to the fetus, thereby depriving the fetus of oxygen essential to growth and development and leading to a low-weight, frail baby—the kind that smoking mothers often give birth to. Anesthetics could likewise deprive fetuses of needed oxygen and lead to miscarriages and birth defects, especially in female anesthetists, who experience considerably more miscarriages and birth defects than do other pregnant women. Anesthetics have been shown to bind to cytochrome P-450 by Burns and others.

There are, in fact, a number of compounds in the environment that might interfere with the oxygen carrier mechanism—insecticides, tranquilizers, polychlorinated biphenyls, plasticizers, fluorocarbons and others. Burns and Gurtner will now investigate the effects of some of these chemicals on oxygen transport to the fetus. ☐